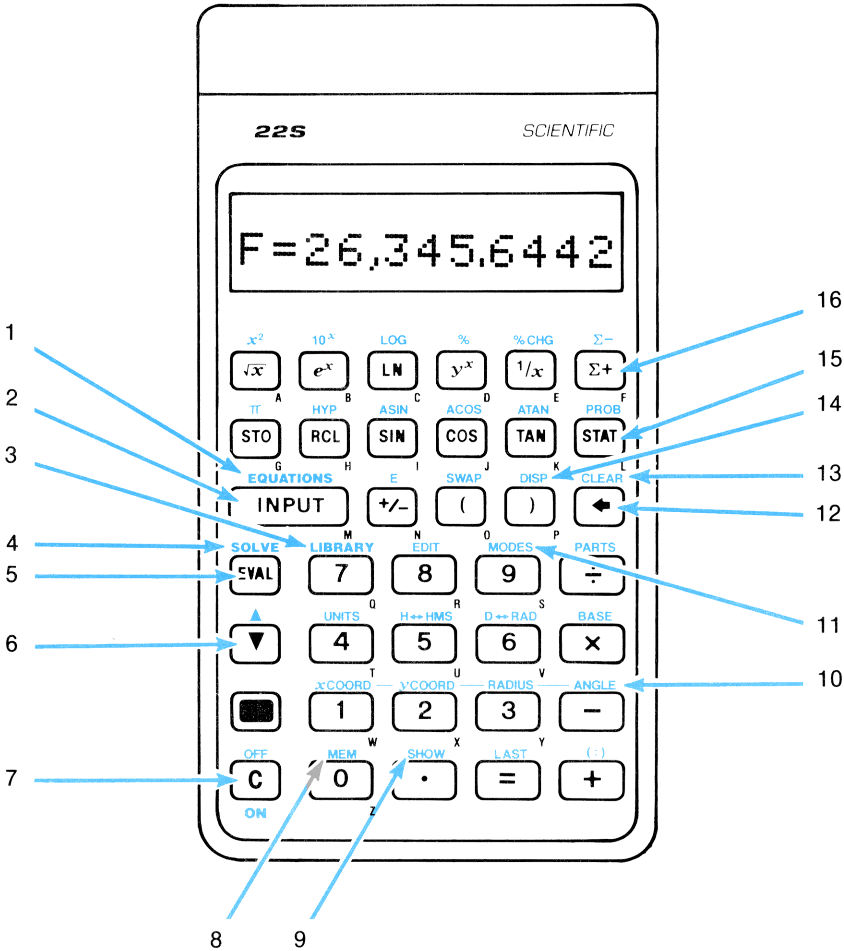
HEWLETT-PACKARD

Scientific Calculator

Owner's Manual

HP-22S

HEWLETT PACKARD



1. List of equations
2. Enter data when **INPUT** annunciator is on
3. Equation library
4. Solve equations for any variable
5. Evaluate equations
6. Move through equation lists
7. ON; clear display, cancel operation
8. Available memory, variables catalog
9. Full precision of number
10. Coordinate conversions
11. Change angular, decimal point modes
12. Backspace
13. Clear portions of memory
14. Display format
15. Statistical functions
16. Enter statistical data

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Each HP calculator comes with an owner's manual. Additional manuals may be ordered separately as well.

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Help Us Help You!

By taking a moment to fill out this card, you can help HP to better understand your needs. Please read all questions first, then fill them out. Thank you.

HELP US HELP YOU!

Model: HP-22S Date acquired ____________________

Name ____________________

Address ____________________

City, State, Zip ____________________

Age ______ Phone (______) ____________________ Business ___ or Home ___

1. What is your POSITION OR OCCUPATION? **(Please check only one)**

- 101 ☐ Student
- 102 ☐ Educator, Researcher
- 103 ☐ Professional Staff
- 104 ☐ Middle Manager
- 105 ☐ Top Manager
- 106 ☐ Owner, Principal, VP
- 107 ☐ Field Agent, Rep
- 108 ☐ Technician
- 109 ☐ Independent, self-employed
- 110 ☐ Retired
- 111 ☐ Other ____________

2. What is your AREA OF ACTIVITY or FIELD OF WORK/STUDY? **(Please check only one)**

- 201 ☐ Mechanical Engineering
- 202 ☐ Civil Engineering
- 203 ☐ Electrical Engineering
- 204 ☐ Chemical Engineering
- 205 ☐ Other Engineering ____________
- 206 ☐ Surveying
- 207 ☐ Data Processing
- 208 ☐ Quality Control
- 209 ☐ Purchasing, Scheduling, Inventory Cntrl.
- 210 ☐ Accounting, Auditing
- 211 ☐ Finance, Investment Analysis
- 212 ☐ General Administration/Management
- 213 ☐ Marketing
- 214 ☐ Sales
- 215 ☐ Customer Service, Maintenance
- 216 ☐ Other ____________

3. In what INDUSTRY do you work? **(Skip if Student or Retired. Please check only one)**

- 301 ☐ Education
- 302 ☐ Banking, Finance, Investment
- 303 ☐ Insurance
- 304 ☐ Real Estate
- 305 ☐ Business/Consulting Services
- 306 ☐ Technical Consulting
- 307 ☐ Software, Computer Services
- 308 ☐ Construction, Architectural
- 309 ☐ Mining, Oil Drilling, Exploration
- 310 ☐ Chemical, Refining
- 311 ☐ Agriculture, Forestry, Livestock
- 312 ☐ Food Processing/Distribution
- 313 ☐ Manufacturing Industrial Goods
- 314 ☐ Manufacturing Consumer Goods
- 315 ☐ Transportation
- 316 ☐ Communication, Utilities
- 317 ☐ Public Admin./Government/Military
- 318 ☐ Other ____________

4. Where did your purchase your HP calculator? **(Please check only one)**

- 401 ☐ Retail Computer Store
- 402 ☐ Office Equipment Store
- 403 ☐ Bookstore
- 404 ☐ Department Store
- 406 ☐ Catalog Store
- 407 ☐ Mail Order
- 408 ☐ Specialty Store
- 409 ☐ Purchased by Company/School
- 410 ☐ Directly from HP
- 411 ☐ Other ____________

5. How did you first hear about this model?

- 501 ☐ Previous HP Owner
- 502 ☐ Advice of Friends, Collegues, Professor
- 503 ☐ Magazine or Newspaper Advertising
- 504 ☐ Press Articles
- 505 ☐ Direct Mail
- 506 ☐ Salesperson
- 507 ☐ Brochure or In Store Literature
- 508 ☐ Other ____________

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Comments on the HP-22S Owner's Manual

We welcome your evaluation of this manual. Your comments and suggestions help us improve our publications.

HP-22S Owner's Manual

Printing date of the manual (from the title page) ________________

Please circle a response for each of the statements below. You can use the **Comments** space to provide additional opinions.

1 = Strongly Agree   4 = Disagree
2 = Agree   5 = Strongly Disagree
3 = Neutral

■ The manual is well organized.	1	2	3	4	5
■ I can find the information I want.	1	2	3	4	5
■ The information in the manual is accurate.	1	2	3	4	5
■ I can easily understand the instructions.	1	2	3	4	5
■ The manual contains enough examples.	1	2	3	4	5
■ The examples are appropriate and helpful.	1	2	3	4	5
■ The layout and format are attractive and useful.	1	2	3	4	5
■ The illustrations are clear and helpful.	1	2	3	4	5

■ The manual length is: too long appropriate too short.

■ The chapter(s) and appendixes I refer to most frequently are:

1 2 3 4 5 6 7 8 A B C

Comments: ________________

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Name: ________________

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HP-22S
Scientific Calculator

Owner's Manual

HEWLETT
PACKARD

Edition 1 March 1988
Reorder Number 00022-90015

Notice

For warranty and regulatory information, see pages 150 and 153.

Corvallis Division
1000 N.E. Circle Blvd.
Corvallis, OR 97330, U.S.A.

Printing History

Edition 1 March 1988 Mfg. No. 00022-90016

Welcome to the HP-22S

Your HP-22S reflects the superior quality and attention to detail in engineering and manufacturing that have distinguished Hewlett-Packard products for more than 40 years. Hewlett-Packard stands behind this calculator: we offer expertise to support its use (see inside the back cover), accessories, and worldwide service.

Hewlett-Packard Quality

Our calculators are made to excel, to last, and to be easy to use.

- This calculator is designed to withstand the usual drops, vibrations, pollutants (smog, ozone), temperature extremes, and humidity variations that it may encounter in normal, everyday use.
- The calculator and its manual have been designed and tested for ease of use. We use spiral binding to let the manual stay open to any page, and we include many examples to highlight the varied uses of this calculator.
- Advanced materials and permanent, molded key-lettering provide a long keyboard life and a positive feel to the keyboard.
- CMOS (low-power) electronics and the liquid-crystal display allow the HP-22S to retain data while it is off, and let the batteries last a long time.
- The microprocessor has been optimized for fast and reliable computations. The calculator uses 15 digits internally for precise results.
- Extensive research has created a design that has minimized the adverse effects of static electricity—a potential cause of malfunctions and data loss in calculators.

Features

The HP-22S's features reflect the needs and wishes we solicited from customers:

- A 12-character, alphanumeric display that provides you with a variety of information—messages, prompts, labels, and, of course, numbers.
- Menus that greatly expand the number of functions available and make them easy to find.
- A broad range of numeric functions, including coordinate, base, and unit conversions.
- The [EVAL] and [SOLVE] functions, which allow you to compute the value of any variable in an equation.
- A library of built-in equations, and an equation list that lets you store your own equations.
- Statistical functions, including mean, standard deviation, weighted mean, and linear regression and estimation.
- Twenty-six storage registers, and enough memory to store statistical data and your own equations.

Contents

Appendices & Index

How to Use This Manual

The HP-22S is designed to minimize your need to use the manual. In fact, we've written the manual to help you learn about the calculator by using it.

We have some suggestions for using the manual effectively:

- Read chapter 1 for an overview of how the HP-22S works. It introduces terms and concepts used throughout the manual.
- There are several ways to locate information: the table of contents, the subject index, and function index.
- Browse through the examples in chapters 7 and 8. You may see a keystroke example you can use. Just as important, you may find some ideas for putting the HP-22S to work for you.

1

Getting Started

Power On and Off

The HP-22S is powered by three alkaline batteries. The calculator is shipped with batteries installed.

To turn on the calculator, press [C] (the key above the "ON" label). To turn the calculator off, press the ■ (shift) key, then [C] (also written ■ [OFF]). Since the calculator has *Continuous Memory*, turning it off does not affect the information you've stored. To conserve energy, the calculator turns itself off approximately 10 minutes after you stop using it.

Under most conditions, the calculator's batteries last well over a year. If you see the low-battery symbol (▭) in the display, replace the batteries as soon as possible. See appendix A for instructions.

The Display Contrast

To change the display contrast, hold down [C] and press [+] or [−].

Simple Calculations

This section introduces simple arithmetic calculations. See chapter 2 for additional information.

If you make a typing mistake, press [◄] to backspace to the wrong character.

Arithmetic Operators. The following examples demonstrate using the arithmetic operators—[+], [−], [×], [÷], and [y^x] (exponentiation).

Keys:	**Display:**	**Description:**
24.715 [+] 62.471 [=]	`87.1860`	Adds 24.715 and 62.471.

When a calculation has been completed (by pressing [=]), pressing a number key starts a new calculation.

19 [×] 12.68 [=]	`240.9200`	Calculates 19 × 12.68.

[y^x] displays the exponentiation operator, ^.

4.7 [y^x] 3	`^ 3`	[y^x] displays ^.
[=]	`103.8230`	Calculates 4.7^3.

If you press an operator key after completing a calculation, the calculation is continued:

[+] 115.5	`+ 115.5`	Continues the calculation.
[=]	`219.3230`	Completes the calculation.

You can do "chain" calculations without using [=] after each step.

6.9 [×] 5.35 [÷]	`36.9150÷`	Pressing [÷] displays the intermediate answer.
.918	`÷ 0.918`	Continues the calculation.
[=]	`40.2124`	Completes the calculation.

Chain calculations are interpreted according to the priority of the operators in the expression (see page 000 for more information).

4 [+] 9 [×]	9.0000×	The addition is delayed; [×] has higher priority than [+].
3 [=]	31.0000	Calculates 4 + (9 × 3).

Negative Numbers. There are two ways to key in a negative number:

- Key in the number and press [+/-].
- If the number follows an operator, you can press [+/-] or [-] before keying in the number.

Keys:	**Display:**	**Description:**
Calculate −75 ÷ 3:		
75 [+/-]	-75	Changes the sign of 75.
[÷] 3 [=]	-25.0000	
Calculate 4.52 × −7.1 ÷ 12:		
4.52 [×] [-] 7.1	×-7.1	[-] after [×] changes the sign of 7.1.
[÷]	-32.0920÷	4.52 × −7.1.
12 [=]	-2.6743	Completes the calculation.
Calculate .4 − $e^{-1.1}$		
.4 [-] [+/-] 1.1	--1.1	
[e^x]	-0.3329	Calculates $e^{-1.1}$.
[=]	0.0671	Completes the calculation.

Understanding the Display and Keyboard

The Cursor

The cursor (_) is visible during *digit entry*—that is, when you are in the process of keying in a number. The cursor is also visible when you are keying in an equation. (Entering equations is introduced later in this chapter.)

Correcting and Clearing the Display ([◀] and [C])

When the cursor is on, or when you've just keyed in an operator, [◀] deletes the last character you keyed in. Otherwise, [◀] clears the entire number.

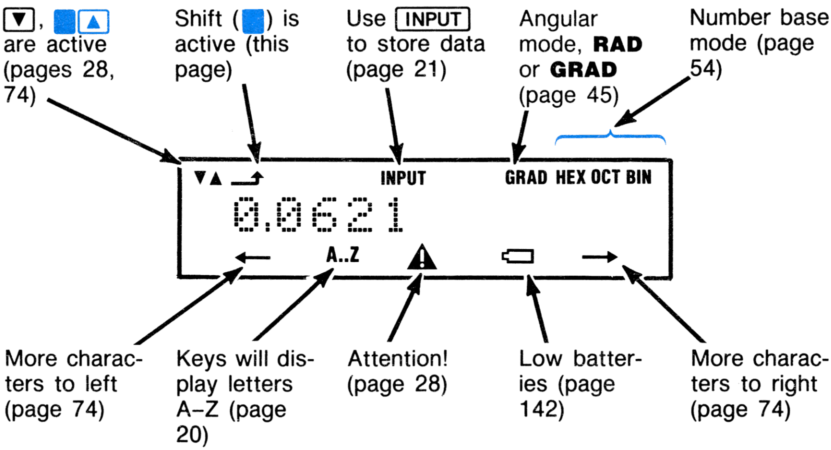
During digit entry, [C] clears the number you are keying in. Otherwise, [C] clears the display of its current contents and cancels the current calculation.

Clearing Messages and Menus. [◀] and [C] also clear messages and menus:

- When the HP-22S is displaying a message, [◀] or [C] clears the message and restores the original contents of the display.
- When the HP-22S is displaying a menu, [◀] or [C] cancels the menu. In multilevel menus, [◀] backs out one level at a time, while [C] cancels all menus and restores the original display. (See "Menus and Pointers" on page 16.)

Annunciators

The annunciators indicate the current status of the calculator.



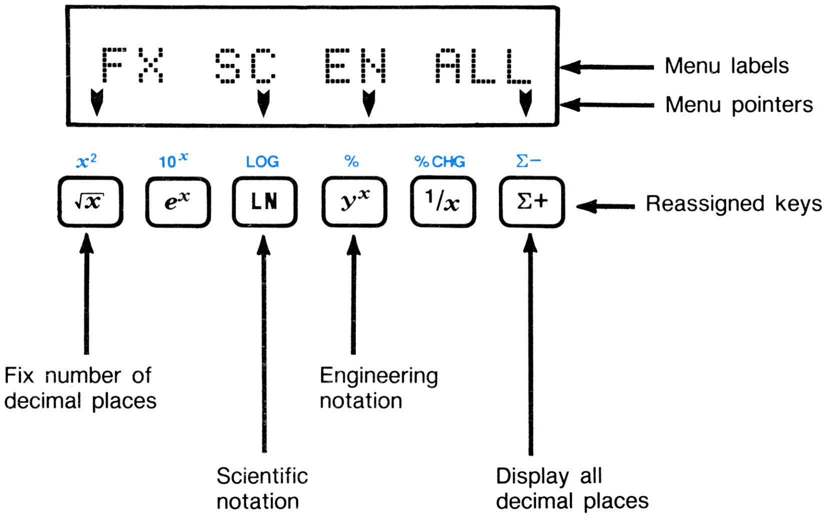
The ■ (Shift) Key

Most keys have a second function printed above the key. The shift key accesses these operations. To do a "shifted" operation, press and release ■ to turn on the shift annunciator (⮥). Then, press the key. For example, pressing ■ followed by [C] (also written ■[OFF]) turns the calculator off.

If you accidentally press ■, press ■ again to turn off the shift annunciator.

Menus and Pointers

The HP-22S uses *menus* to extend the functionality of the keyboard. For example, pressing ■[DISP] displays the DISP (*display format*) menu.



The *menu labels* describe new, temporary assignments for keys on the top row of the keyboard. The *menu pointers* indicate which keys are currently reassigned. When the HP-22S is displaying a menu, it is waiting for you to select one of the menu options by pressing one of the reassigned keys. The manual uses curly braces to indicate keys reassigned by menus. For example, the DISP menu reassigns $\boxed{\sqrt{x}}$ to {FX} (FIX).

The following table lists the HP-22S menus. Notice that the keys listed in the table are highlighted on the keyboard.

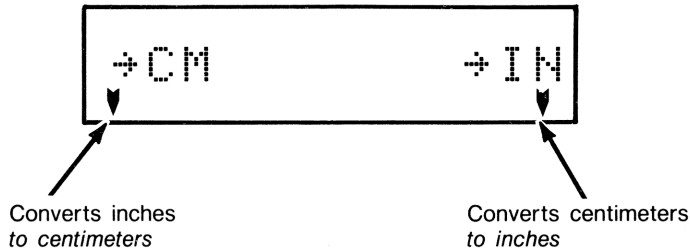
HP-22S Menus

Keys	Description	See chapter:
[STAT]	Statistics (summation statistics, mean, standard deviation, linear regression) using the contents of the statistics registers.	5
[PROB]	Probability: factorial, combinations, permutations.	3
[UNITS]	Unit conversions: mass (kilograms/pounds), temperature (°C/°F), length (centimeters/inches), volume (liters/gallons).	3
[H↔HMS]	Hours.Decimal hours/ Hours.MinutesSeconds conversions.	3
[D↔RAD]	Degrees/radians conversions.	3
[PARTS]	Number-altering functions: integer part, fractional part, round, absolute value	3
	Other Operations	
[DISP]	Display format: FIX, scientific, engineering, all digits.	1
[CLEAR]	Clear: variables, equations, all of memory, statistics.	1
[MODES]	Modes: angular (Degrees/Radians/Grads), decimal point and digit separator (period/comma).	1, 3
[MEM]	Memory: available memory, variables catalog.	1
[BASE]	Base conversions: decimal, hexadecimal, octal, and binary modes.	4

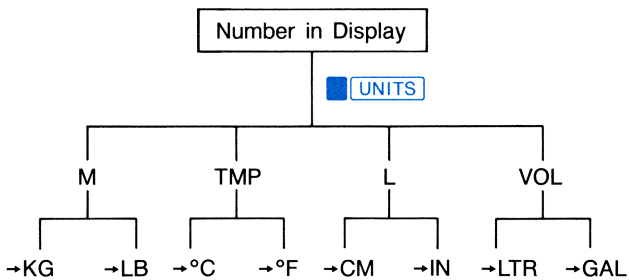
Multi-Level Menus. Some menus have more than one "level." For example, pressing [UNITS] displays the UNITS (*unit conversion*) menu:

```
M      TMP  L     VOL
```

Each of the four keys in the UNITS menu displays another menu. For example, pressing {L} displays the L (*length*) menu, which contains the two length conversion functions:



The following *menu map* illustrates the UNITS menu and the menus that "branch" from it.

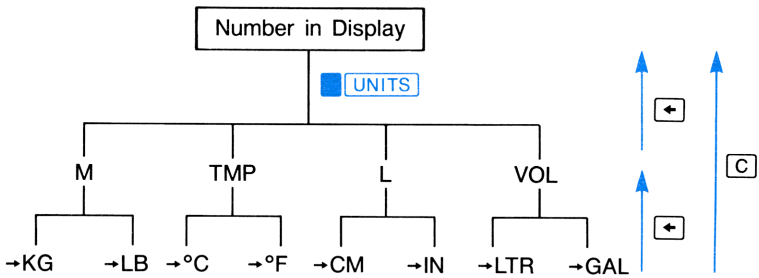


These keystrokes show how to convert 12.7 inches to centimeters:

Keys:	**Display:**	**Description:**
12.7 ■ UNITS	M TMP L VOL	Keys in the number, displays the UNITS menu.
{L}	→CM →IN	Displays the *length* menu.
{→CM}	32.2580	32.2580 centimeters is equivalent to 12.7 inches.

Canceling Menus. Canceling a menu erases the current menu labels. There are several ways to cancel menus:

- Menus are automatically canceled when you press a menu key to execute a function.
- [◆] cancels the menu without executing a function. In multi-level menus, [◆] backs up one level at a time.
- [C] cancels the menu, regardless of what level it is at.
- Menus replace one another. For example, if you accidently press ■[MODES] instead of ■[UNITS], you can press ■[UNITS] without first canceling the MODES menu.



The Letter Keys and Variables

Most of the keys have a letter *A* through *Z* associated with them. Each letter is the name of a calculator *variable*. The 26 variables are locations in calculator memory used to store and retrieve numbers.

Pressing [STO] (*store*) or [RCL] (*recall*) turns on the **A..Z** annunciator to let you know that the keys are using their letter assignments. For example, 12 [STO] turns on the **A..Z** annunciator. Then, pressing [√x] displays A=12.0000, indicating that 12 has been stored into variable *A*. This series of keystrokes is written as 12 [STO] A.

Storing and retrieving numbers using variables is covered in more detail in chapter 2. Using variables with [EVAL] and [SOLVE] is covered in chapter 6.

The [INPUT] Key

The [INPUT] key is used with:

- Two-number functions, to enter the first number (see "Two-Number Functions," below).
- Two-variable statistics, to enter the x-value (see page 61).
- [EVAL] and [SOLVE], to enter equations and store values into variables (see page 73).

Introduction to the Math Functions

Many of the math functions are visible on the keyboard. Menus increase the number of available functions. Chapter 3 describes the numeric functions in more detail.

One-Number Functions. Math functions involving one number use the number you most recently keyed in.

Keys:	Display:	Description:
89.25 [√x]	9.4472	Calculates $\sqrt{89.25}$.
3.57 [+] 2.36 [1/x]	+0.4237	Calculates 1/2.36.
[=]	3.9937	Completes the calculation.
180 ■ [D↔RAD] {→RAD}	3.1416	Converts 180° to radians.

Two-Number Functions. When a function requires two numbers, they are entered by the keystrokes $number_1$ [INPUT] $number_2$. Pressing [INPUT] displays a colon to separate the two numbers.

Calculate the percent change between 17 and 29:

Keys:	**Display:**	**Description:**
17 [INPUT]	17.0000:	Enters *number*$_1$.
29	: 29	Colon precedes *number*$_2$.
■ [%CHG]	70.5882	Calculates the percent change.

Calculate the number of combinations of 4 items taken 2 at a time:

4 [INPUT] 2 ■ [PROB] {Cn,r}	6.0000	Calculates number of combinations.

Display Mode and Format of Numbers

When you turn on the HP-22S for the first time, numbers are displayed with four decimal places and a period as the decimal point. The *display format* controls how numbers appear in the display.

Regardless of the current display format, each number is stored as a signed, 12-digit mantissa with a signed, three-digit exponent.* For example, pressing ■ [π] in FIX 4 mode (4 decimal places) displays 3.1416. Internally, the number is stored as $3.14159265359 \times 10^{000}$.

If a number doesn't fit in the current display format, the displayed number is rounded to fit.

* During complex internal calculations, the HP-22S uses 15-digit precision for intermediate results.

Specifying the Number of Displayed Decimal Places

To specify (*fix*) the number of displayed decimal places:

1. Press ■ DISP, then {FX}.
2. Key in the number of digits to the right of the decimal point. For 10 or 11 places, key in .0 or .1.

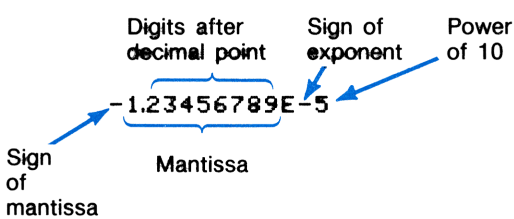
Keys:	**Display:**	**Description:**
45.6 × .1256 = ■ DISP {FX} 3	5.727	Displays 3 decimal places.
■ DISP {FX} .0	5.7273600000	Displays 10 decimal places.
■ DISP {FX} 4	5.7274	Restores 4 decimal places.

When a number is too large or too small to be displayed in FIX format, it is displayed in scientific notation.

Scientific and Engineering Notation

Scientific and engineering notation express the number as a mantissa multiplied by a power of 10. The letter E separates the exponent from the mantissa.

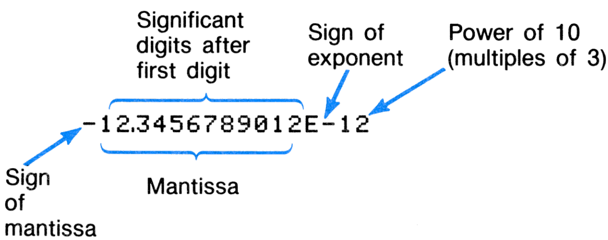
Scientific Notation. Scientific notation uses a mantissa with one digit to the left of the decimal point.



To specify scientific notation:

1. Press ■ DISP, then {SC}.
2. Key in the number of digits to the right of the decimal point.* For 10 or 11 places, key in .0 or .1.

Engineering Notation. Engineering notation expresses a number as a mantissa with one, two, or three digits to the left of the decimal point, multiplied by 10 raised to a power divisible evenly by 3.



To specify engineering notation:

1. Press ■ DISP, then {EN}.
2. Key in the number of significant digits after the first digit.* For 10 or 11 digits, key in .0 or .1.

* The maximum number of decimal places that can be displayed is 9. However, {SC} (or {EN}) 10 or 11 retains the 10th and 11th digits when the {RN} (*round*) function is used.

Keying in Numbers With Exponents. Regardless of the current display format, you can always key in a number as a mantissa followed by an exponent:

1. Key in the mantissa. If the mantissa is negative, use [+/-] to change the sign.
2. Press ■ [E] to start the exponent.
3. If the exponent is negative, press [-] or [+/-].
4. Key in the exponent.

Keys:	**Display:**	**Description:**
Calculate $4.78 \times 10^{13} \div 8 \times 10^{25}$:		
4.78 ■ [E] 13 [÷]	`4.7800E13÷`	
8 ■ [E] 25 [=]	`5.9750E-13`	5.9750×10^{-13}.
Calculate $-2.36 \times 10^{-15} \times 12$:		
2.36 [+/-] ■ [E] [-] 15 [×] 12 [=]	`-2.8320E-14`	-2.832×10^{-14}.

Displaying All the Non-Zero Digits

To display numbers as precisely as possible, press ■ [DISP] {ALL}.

Interchanging the Period and Comma

You can interchange the period and comma used as the decimal point and digit separator. For example, one million can be displayed:

`1,000,000.0000` or `1.000.000,0000`

To change the decimal point and digit separator, press ■ [MODES]. Specify the decimal point by pressing { . } or { , }.

Showing Numbers ([SHOW])

Viewing All 12 Digits. To temporarily view all 12 stored digits of the number in the display, press and then hold down [SHOW]. If the 12-digit version of the number fits in the display, the number is shown. However, if the number doesn't fit, the 12 digits are shown without the decimal point.

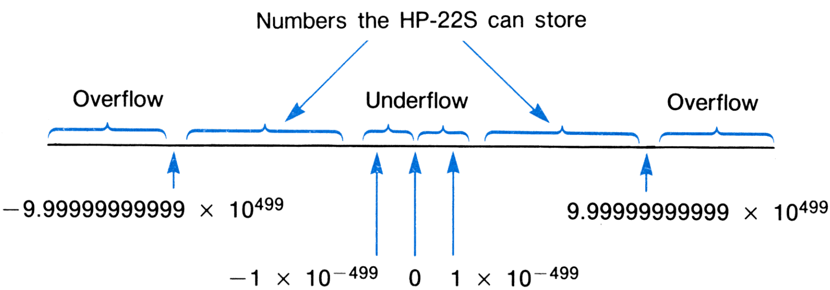
Keys:	**Display:**	**Description:**
10 [÷] 7 [=]	1.4286	
[SHOW]	1.42857142857	Displays 12-digit number.
1 [÷] 80 [=]	0.0125	
[SHOW]	125000000000	Displays the 12 digits.

Viewing Labels For Long Results. If a labeled number has too many characters to fit in the display, the HP-22S briefly displays the label, and then displays the value. Use [SHOW] to view the label again.

Keys:	**Display:**	**Description:**
[DISP] {ALL}		
10 [÷] 30 [=] [STO] A	A=	Label displayed briefly.
	3.33333333E-1	Value displayed.
[SHOW]	333333333333	Shows all 12 digits.
	A=	Shows label again.
	3.33333333E-1	Value displayed.

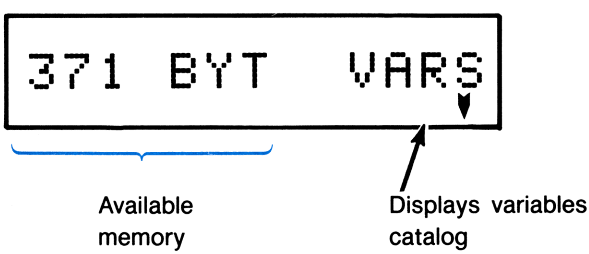
Range of Numbers

The following illustration shows the range of numbers the HP-22S can store. Underflow displays 0. Overflow displays a warning and the largest positive or negative number possible.



The MEM Function (MEM)

Pressing MEM displays the amount of unused calculator memory, and lets you access the variables catalog. Press C or ◆ to erase the message.



Available Memory

The HP-22S has 371 units, or *bytes* of memory available for your use. If you attempt an operation that requires more memory than you currently have available, the HP-22S displays MEMORY FULL. You must clear a portion of your previously stored information before proceeding (see the next two sections).

The VARS (Variables) Catalog

The {VARS} menu key displays a catalog of variables containing non-zero values. Press [▼] or ■[▲] to see the entire catalog. Press [C] to exit the catalog. (See page 40 for additional information.)

Clearing Portions of Memory

Pressing ■[CLEAR] displays the CLEAR menu (except while viewing an equation or the VARS catalog).

The CLEAR Menu

Key	Description
{VAR}	Clears all variables. (Clearing individual variables is covered in chapter 2.)
{EQ}	Clears all equations and expressions you've entered into the list of equations.
{ALL}	Clears everything you've stored in memory (variables, statistics values, equations you've entered, and the number in the display).
{Σ}	Clears all the statistical registers.

Pressing {VAR}, {EQ} or {ALL} displays a confirmation message:

```
CL VARS? Y N    CL EQNS? Y N    CLR ALL? Y N
```

{N} allows you to recover from what might otherwise be an unpleasant mistake.

Messages and the Attention Annunciator

When you perform certain operations, the attention annunciator (▲) comes on and the HP-22S displays a message. The attention annunciator also comes on when you attempt an incorrect operation, and when the calculator is ignoring an inappropriate keystroke. See page 173 for a list of messages and their meanings.

Introduction to [EVAL] and [SOLVE]

[EVAL] lets you evaluate an algebraic expression, or evaluate an equation for a variable that appears by itself on the left side of the equation. [SOLVE] lets you solve an equation for any variable.

Writing and Entering an Equation

The equation for calculating the period of a simple pendulum (a pendulum made from a very small object suspended by a very light string) is:

$$T = 2\pi\sqrt{\frac{l}{g}}$$

where T = the period of the pendulum.
l = the length of the string.
g = the acceleration of gravity, 9.80665 meters/sec^2.

The equation must be written in a form the HP-22S can interpret:

Equation functions

`T=2×π×SQRT(L÷G)`

The following keystrokes enter the equation:

Keys:	Display:	Description:
■ [EQUATIONS]	`TYPE NEW EQN`	If the list of equations already contains equations, press [▼] until the HP-22S displays this message.
[STO] T	`T`	Use [STO] or [RCL] to type a letter.

[=] 2 [×] [■] [π]	T=2×π	"π" is a function; typing functions use the same keys as math calculations.
[×] [√x]	T=2×π×SQRT(	[√x] types SQRT(.
[STO] L [÷] [STO] G [)]	π×SQRT(L÷G)	Equation scrolls.
[INPUT]	T=2×π×SQRT(L	Enters the equation.

Evaluating an Equation

Example: Period of a Pendulum. Part 1: Calculate the period of a pendulum 3 meters long.

Keys:	**Display:**	**Description:**
[EVAL]	L?*value*	Prompts for *L* and displays current value of *L*.
3 [INPUT]	L=3.0000 G?*value*	Stores *L*, prompts for *G*.
9.80665 [INPUT]	G=9.8067 T=3.4752	Stores *G*, calculates *T* (seconds).

Part 2: Calculate the period if the pendulum is lengthened to 4 meters.

[EVAL]	L?3.0000	Prompts for *L*.
4 [INPUT]	G?9.8067	Stores *L*, prompts for *G*.
[INPUT]	T=4.0128	Retains previous value of *G*; calculates *T*.

Solving an Equation

When the unknown is not by itself on the left side of the equation, use [SOLVE]. Pressing ■ [SOLVE] displays a menu of the equation's variables. Use the menu to select the unknown.

Example: Length of a Pendulum. What length must a pendulum be to have a period of 8 seconds?

Keys:	Display:	Description:
■ [SOLVE]	`G L T`	Menu for selecting the unknown variable.
{L}	`T?4.0128`	Selects *L*, prompts for *T*.
8 [INPUT]	`G?9.8067`	Stores *T*, prompts for *G*.
[INPUT]	`L=15.8979`	Retains previous value of *G*, calculates *L*.*

* If the HP-22S displays `SQRT(NEG)` instead of the answer, there was a negative value stored in *L* before you started the calculation. Clear *L* (press 0 [STO] L) and start again.

2

Arithmetic and Variables

Arithmetic Operators

The following keystrokes illustrate simple arithmetic operations:

Keys:	**Display:**	**Description:**
54.69 [+] 28.33 [=]	83.0200	Addition.
750 [×] 12 [=]	9,000.0000	Multiplication; pressing a number key after [=] starts a new calculation.
[÷] 360 [=]	25.0000	Division; pressing an operator key after [=] continues the calculation.
5 [y^x] 4 [=]	625.0000	Exponentiation.

Chain Calculations

Chain calculations do a sequence of operations without pressing [=] after each operation. The HP-22S interprets expressions using the system of *operator priority* described in the next section.

Keys:	Display:	Description:
750 [×] 12 [÷]	9,000.0000÷	Calculates intermediate value.
360 [=]	25.0000	Completes the calculation.

Operator Priority

Some chain calculations might be interpreted several different ways. For example, $9+12\div3$ has two interpretations:

$$9 + \frac{12}{3} \quad \text{or} \quad \frac{9 + 12}{3} = 7$$

The HP-22S uses a system of operator priority to evaluate expressions:

[y^x] (exponentiation)	Highest priority
[×] [÷]	↓
[+] [−]	Lowest priority

The HP-22S calculates an intermediate result when the next operator you key in has lower or equal priority. When the next operator has higher priority, the HP-22S retains the previous number(s). For example, the calculation:

9 [+] 12 [÷] 3 [=]

is performed as $9 + (12 \div 3)$ because division has higher priority than addition.

Keys:	Display:	Description:
9 [+] 12 [÷]	12.0000÷	Pressing [÷] *does not* add 9 + 12.
3 [=]	13.0000	

Calculate 4×7^3 plus 5×7^2 plus 6.

4 [×] 7 [y^x]	7.0000^	[y^x] has higher priority than [×].
3 [+]	1,372.0000+	Calculates 4×7^3.
5 [×]	5.0000×	[×] has higher priority than [+].
7 [y^x]	7.0000^	[y^x] has higher priority than [+].
2	^ 2	
[+]	1,617.0000+	Adds 5×7^2 to 1,372.
6 [=]	1,623.0000	Completes the calculation.

If a calculation requires that operations be done in an order inconsistent with operator priority (for example, addition *before* multiplication), use parentheses.

Using Parentheses in Calculations

Use parentheses to group operations and to specify the order in which they are performed.* For example, you can calculate:

$$\frac{9 + 12}{3}$$

by placing parentheses around the addition so that it is done before the division:

* Closing parentheses at the end of the expression can be omitted. For example, 25÷(3×(9+12 [=] is equivalent to 25÷(3×(9+12)) [=].

Keys:	Display:	Description:
[(] 9 [+] 12 [)]	21.0000	[)] evaluates contents of parentheses.
[÷] 3 [=]	7.0000	

Calculate $\frac{30}{85 - 12} \times \sqrt{16.9 - 8}$:

Keys:	Display:	Description:
30 [÷] [(]	÷(	
85	(85	
[−]	85.0000−	[(] prevented division of 30 by 85.
12 [)]	÷73.0000	[)] evaluates contents of parentheses (85 − 12).
[×]	0.4110×	Calculates 30 ÷ 73.
[(] 16.9	(16.9	
[−] 8 [)]	×8.9000	[)] evaluates (16.9 − 8).
[√x]	×2.9833	Calculates $\sqrt{8.9}$.
[=]	1.2260	Completes the calculation.

Reusing the Previous Result (■ LAST)

When you start a new calculation, a copy of the most recent result is stored in the LAST register. To recall that value to the display, press ■ LAST. For example, LAST shortens the following two calculations:

$$.0821 \times (18+273.1)$$

$$2 + \frac{13}{.0821 \times (18 + 273.1)}$$

Keys:	Display:	Description:
.0821 × (18 + 273.1) =	23.8993	First result.
2 + 13 ÷ ■ LAST	÷23.8993	■ LAST recalls the previous result.
=	2.5439	Second result.

Swapping the Displayed Number With the Previous Number

■ SWAP exchanges the last two numbers you've keyed in during a calculation. For example, if you've keyed in 44 ÷ 75, ■ SWAP reverses the order of the numbers to 75 ÷ 44. Pressing ■ SWAP again restores 44 ÷ 75.

Keys:	Display:	Description:
44 ÷ 75	÷ 75	Oops! You meant to key in 75 ÷ 44.
■ SWAP	÷44.0000	Swaps the 75 and 44.
=	1.7045	Completes the calculation.

8 [+] 4 [÷] 5	÷ 5	Stop! You really want to add 8 + 5/4.
[■][SWAP]	÷4.0000	Swaps the 5 and 4.
[=]	9.2500	Completes the calculation.
7 [×] [(] 6 [−] 9	- 9	No! You meant 9 − 6!
[■][SWAP] [=]	21.0000	Calculates 7 × (9 − 6).

An important use of [■][SWAP] is with functions that require two numbers separated by [INPUT]. For example, to accumulate *x,y*-data in the statistics registers, you key in *x*-value [INPUT] *y*-value [Σ+]. Pressing [■][SWAP] (before you've pressed [Σ+]) exchanges *x*-value and *y*-value.

Variables (Registers)

The HP-22S has 26 registers, or "variables," for storing and recalling numbers. The variables are identified by the letters *A* through *Z*. (The same 26 variables are used to enter, evaluate, and solve equations; see chapter 6.)

Pressing [STO] or [RCL] turns on the **A..Z** annunciator, indicating that the keys are now using their letter assignments.

- [STO] *letter* stores a copy of the displayed number into the designated variable.* The number is copied with full precision (all 12 digits). The new value overwrites the previous contents of the variable.
- [RCL] *letter* copies the current value stored in the variable to the display.* The number is displayed in the current display format.

[STO] *letter* and [RCL] *letter* display labeled values (for example, A=1.2345), unless the store or recall is done in the middle of a calculation (see the following example).

* During equation entry, [STO] *letter* and [RCL] *letter* type the specified letter (see page 73).

To cancel store or recall after you've pressed [STO] or [RCL], press [◆] or [C].

The following keystrokes use variables *A* and *B* to calculate:

$$\frac{(27.1 + 35.6) \times 1.0823}{(27.1 + 35.6)^{1.0823}}$$

Keys:	**Display:**	**Description:**
27.1 [+] 35.6 [=]	62.7000	
[STO] A	A=62.7000	Stores 62.7 in *A*.
[×]	62.7000×	[×] erases the label and continues the calculation.
1.0823 [STO] B	×1.0823	No label is displayed when [STO] occurs in the middle of a calculation.
[÷]	67.8602÷	Numerator is computed.
[RCL] A	÷62.7000	Recalls contents of *A*.
[y^x] [RCL] B	^1.0823	Recalls contents of *B*.
[=]	0.7699	Exponentiation is done before division.

Storage Arithmetic With Variables

These arithmetic operations can be performed on numbers stored in variables.

Storage Arithmetic

Keys	New Number in Variable
STO + *letter*	Previous value + displayed number
STO − *letter*	Previous value − displayed number
STO × *letter*	Previous value × displayed number
STO ÷ *letter*	Previous value ÷ displayed number

The following keystrokes use variables *C* and *D* to do two calculations:

$$1.097 \times 25.6671$$
$$1.097 \times 35.6671$$

Keys:	**Display:**	**Description:**
1.097 STO C	C=1.0970	Stores 1.097 in *C*.
× 25.6671 STO D	×25.6671	Stores 25.6671 in *D*.
=	28.1568	First answer.
RCL C	C=1.0970	Recalls *C*.
× 10 STO +	STO + _	Calculator awaits letter.
D	×10.0000	Adds 10 to *D*.
RCL D	×35.6671	Contents of *D* replaces 10.0000.
=	39.1268	Second answer.

The VARS (Variables) Catalog

When you store a non-zero value in a variable, a portion of calculator memory is *allocated* to the variable. The VARS catalog, which is viewed by pressing ■ [MEM] {VARS}, lists all the allocated variables and their values. Press [▼] or ■ [▲] to "roll" through the entire catalog. To cancel the catalog, press [C].

To use a variable directly from the catalog, press [RCL] while the variable is displayed.

Keys:	**Display:**	**Description:**
5 [STO] A	A=5.0000	Stores 5 in *A*.
Calculate 9 × *A*:		
9 [×]	9.0000×	Start a calculation.
You want to verify the value of *A* before you use it in the calculation.		
■ [MEM] {VARS}	A=5.0000	Displays *A* in catalog.
[RCL] [=]	45.0000	Calculates 9 × *A*.

Clearing Variables

Clearing variables sets them equal to 0.

Clearing Individual Variables. There are two ways to clear an individual variable:

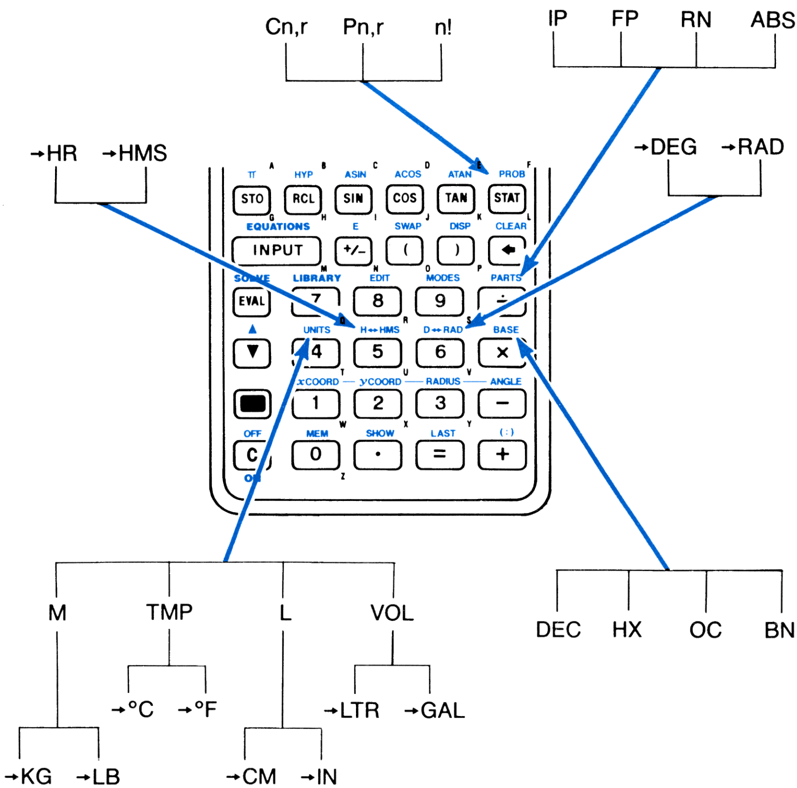
- Display the variable in the VARS catalog (see "The VARS Catalog," above) and press ■ [CLEAR].
- Store zero into the variable.

Clearing All Variables. To clear all the variables, press ■ [CLEAR] to display the CLEAR menu, then {VAR}. Respond {Y} to the prompt.

3

Numeric Functions

Many of the numeric functions are visible on the keyboard—for example, [SIN] (sine), ■ [LOG] (base 10 logarithm). Others are in *function menus.*



Functions require one or two arguments (an argument is a number acted upon by a function):

- Functions with one argument act on the number in the display. For example, 6 [√x] calculates the square root of 6. A function cannot be executed when the last character keyed in is an operator. For example, you cannot key in 6 [+] and then press [√x].
- Functions with two arguments and one result use [INPUT] to separate the arguments. For example, 4 [INPUT] 5 ■ [%CHG] calculates the percent change between 4 and 5. The arguments can be expressions. For example 1 [+] 3 [INPUT] 2 [+] 3 ■ [%CHG] also calculates the percent change between 4 and 5.
- Polar/rectangular coordinate conversions use two arguments and return two results. The HP-22S uses four special registers to store and calculate the coordinates (see page 48).

Power and Logarithmic Functions

The HP-22S has the following power and logarithmic functions.

Power and Logarithmic Functions

Key(s)	Description	Key(s)	Description
[√x]	Square root.	■ [x^2]	Square.
[e^x]	Natural antilogarithm.	■ [10^x]	Base 10 antilogarithm.
[LN]	Natural logarithm.	■ [LOG]	Base 10 logarithm.

Keys:	Display:	Description:
45 [√x]	6.7082	$\sqrt{45}$.
4.5 [+/-] ■ [10^x]	3.1623E-5	Calculates $10^{-4.5}$.
[×] 3.7 [+/-] ■ [10^x]	×0.0002	Calculates $10^{-3.7}$.
[=]	6.3096E-9	Multiplies the two antilogarithms.

Reciprocal

[1/x] calculates the reciprocal of the number in the display.

Keys:	Display:	Description:
3 [1/x] [+] 4 [1/x]	+0.2500	Calculates 1 ÷ 3, 1 ÷ 4.
[=]	0.5833	Adds the two reciprocals.

Percent Functions

Percent

The [■] [%] function performs two different operations:

- If there is no pending operator (no operator or parenthesis precedes the displayed number), or if the pending operator is ×, ÷, or ^, then [■] [%] divides the displayed number by 100.
- If + or − precedes the displayed number, [■] [%] interprets the displayed number as a percent, and returns that percent of the number preceding the + or −.

Calculate 27% of 85.3.

Keys:	Display:	Description:
85.3 [×] 27 [■] [%]	×0.2700	Divides 27 by 100.
[=]	23.0310	Calculates 27% of 85.3.

Find the number that is 25% less than 200.

200 [−] 25 [■] [%]	−50.0000	Calculates 25% of 200.
[=]	150.0000	Completes the calculation.

Percent Change

To calculate the percent change between two numbers, n_1 and n_2, expressed as a percentage of n_1, key in:

n_1 [INPUT] n_2 ■ [%CHG]

Calculate the percent change between 291.7 and 316.8.

Keys:	Display:	Description:
291.7 [INPUT]	291.7000:	Enters n_1. (The colon separates n_1 and n_2.)
316.8 ■ [%CHG]	8.6047	Calculates percent change.

Calculate the percent change between (12 × 5) and (65 + 18).

12 [×] 5 [INPUT]	60.0000:	Calculates and enters n_1.
65 [+] 18 ■ [%CHG]	38.3333	Percent change between 60 and (65 + 18).

Pi (π)

Pressing ■ [π] displays the value of π. Although the displayed value is rounded to the current display format, the 12-digit value is actually used.

Example: Surface Area of a Sphere. Find the surface area of a sphere with radius = 4.5″ (surface area = $4\pi r^2$).

Keys:	Display:	Description:
4 [×] ■ [π]	×3.1416	Displays π.
[×] 4.5 ■ [x^2] [=]	254.4690	Surface area in square inches.

Angular Modes

The "angular" mode determines how numbers are interpreted when using the trigonometric and coordinate conversion functions.

Angular Modes

Keys	Description	Annunciator
■ [MODES] {DG}	Sets *Degrees* mode. There are 360 degrees in a circle. Angles are measured in decimal degrees (rather than degrees-minutes-seconds).	None
■ [MODES] {RD}	Sets *Radians* mode. There are 2π radians in a circle.	**RAD**
■ [MODES] {GR}	Sets *Grads* mode. There are 400 grads in a circle.	**GRAD**

Trigonometric Functions

The angles are interpreted in decimal degrees, radians, or grads, depending on the current angular mode.

Trigonometric Functions

Key(s)	Function	Key(s)	Function
[SIN]	sine	■ [ASIN]	arc sine
[COS]	cosine	■ [ACOS]	arc cosine
[TAN]	tangent	■ [ATAN]	arc tangent

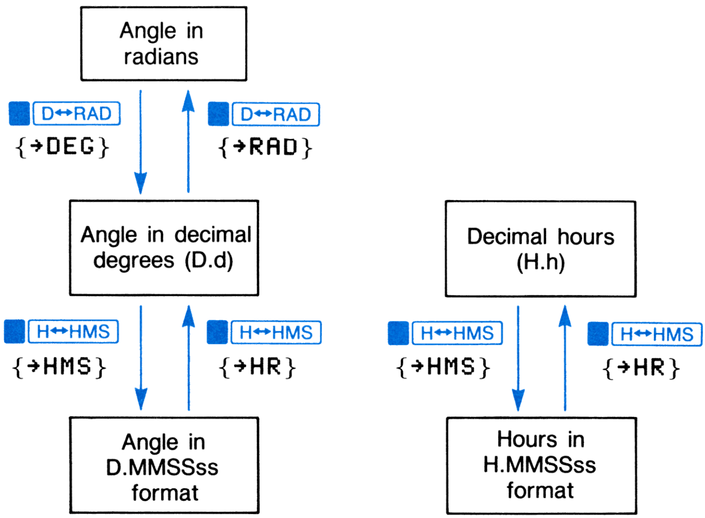
Keys:	Display:	Description:
■ MODES {DG}		Sets Degrees mode.
15 SIN	0.2588	Sine of 15°.
1 + 60 TAN	+1.7321	Tangent of 60°.
=	2.7321	Calculates 1 + tan 60°.
.35 ■ ACOS	69.5127	Arc cosine of .35.
− .62 ■ ACOS	-51.6839	Arc cosine of .62.
=	17.8288	Arc cosine of .35 minus arc cosine of .62.

Angle and Hour Conversions

The HP-22S can do the following angle and hour conversions.

Angle and Hour Conversion Functions

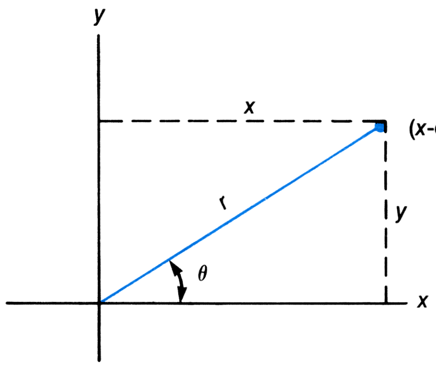
Keys	Function
■ H↔HMS {→HR}	*To hours*; converts the number from hours (or degrees)-minutes-seconds-decimal seconds format (H.MMSSss or D.MMSSss) to decimal hours (or degrees) format.
■ H↔HMS {→HMS}	*To hours-minutes-seconds*; converts the number from decimal hours (or degrees) to hours (or degrees)-minutes-seconds-decimal seconds format (H.MMSSss or D.MMSSss).
■ D↔RAD {→DEG}	*To degrees*; converts the number from a radian value to its decimal degree equivalent.
■ D↔RAD {→RAD}	*To radians*; converts the number from a decimal degree value to its radian equivalent.



Keys:	**Display:**	**Description:**
1.79 × ■ π =	5.6235	Calculates 1.79π.
■ D↔RAD {→DEG}	322.2000	Converts 1.79π radians to degrees.
90.2015 ■ H↔HMS {→HR}	90.3375	Converts 90 degrees, 20 minutes, 15 seconds to decimal degrees.
25.2589 ■ H↔HMS {→HMS}	25.1532	25.2589 degrees = 25 degrees, 15 minutes, 32 seconds.
■ SHOW	25.1532040000	Shows decimal seconds (32.04 seconds).

Polar/Rectangular Coordinate Conversions

Coordinate conversions use the four coordinate conversion registers. In general, if you've just keyed in a number, pressing a coordinate conversion key stores the number in the register. A calculation occurs when you press one coordinate conversion key right after another.



Coordinate Conversion Keys and Registers

Keys	Register	Description:
■ [xCOORD]	x*	Stores the x-coordinate, or calculates the x-coordinate† using the contents of r and θ.
■ [yCOORD]	y*	Stores the y-coordinate, or calculates the y-coordinate† using the contents of r and θ.
■ [RADIUS]	r*	Stores the radius, or calculates the radius† using the contents of x and y.
■ [ANGLE]	θ	Stores the angle, or calculates the angle† using the contents of x and y. The value is interpreted according to the current angular mode—decimal degrees, radians, or grads.

* These storage locations are separate from the variables X, Y, and R.

† Both coordinates are calculated. For example, calculating x changes the contents of both x and y; calculating r changes the contents of both r and θ.

To convert from rectangular to polar coordinates:

1. *Store* the rectangular coordinates: Key in x and press ■ [xCOORD]. Key in y and press ■ [yCOORD].
2. *Calculate* the polar coordinates: Press ■ [RADIUS] and/or ■ [ANGLE].

To convert from polar to rectangular coordinates:

1. *Store* the polar coordinates: Key in r and press ■ [RADIUS]. Key in θ and press ■ [ANGLE].
2. *Calculate* the rectangular coordinates: Press ■ [xCOORD] and/or ■ [yCOORD].

Example: Coordinate Conversions. Part 1: Convert the rectangular coordinates (10, −15) to polar coordinates.

Keys:	**Display:**	**Description:**
■ [MODES] {DG}		Sets Degrees mode.
10 ■ [xCOORD]	x=10.0000	Stores x.
15 [+/-] ■ [yCOORD]	y=-15.0000	Stores y.
■ [RADIUS]	r=18.0278	Calculates r.
■ [ANGLE]	θ=-56.3099	Calculates θ.

Part 2: Convert the polar coordinates (7,30°) to rectangular coordinates:

7 ■ [RADIUS]	r=7.0000	Stores r.
30 ■ [ANGLE]	θ=30.0000	Stores θ.
■ [xCOORD]	x=6.0622	Calculates x.
■ [yCOORD]	y=3.5000	Calculates y.

Part 3: Convert (6, 30°) to rectangular coordinates:

6 ■ [RADIUS]	r=6.0000	Stores r. (30° is still stored in θ.)
■ [xCOORD]	x=5.1962	Calculates x.
■ [yCOORD]	y=3.0000	Calculates y.

Values stored in the coordinate conversion registers remain there until the numbers are overwritten by another coordinate conversion calculation.

Using [STO] and [RCL] With the Coordinate Conversion Registers. You can perform the same store/recall operations on the *x*, *y*, *r*, and *θ* registers as you can with variables. For example, [RCL] ■[RADIUS] recalls the contents of *r*, and 5 [STO] [+] ■[xCOORD] adds 5 to the contents of *x*.

You can use [STO] to "force" a store operation. For example, you can store 3 into both *x* and *y* by pressing 3 ■[xCOORD] [STO] ■[yCOORD]. (If you omitted [STO], pressing ■[yCOORD] would do a calculation.)

Probability Functions

The PROB menu is used to calculate combinations, permutations and factorials.

Combinations and Permutations. The keystrokes for calculating combinations and permutations are:

n-value [INPUT] *r*-value ■[PROB] {Cn,r}

and

n-value [INPUT] *r*-value ■[PROB] {Pn,r}

The number of *combinations* of *n* objects taken *r* at a time is the number of different sets containing *r* items that can be taken from a larger group of *n* items. No item occurs more than once in the set of *r* items, and different orders of the same *r* items *are not* counted separately.

The number of *permutations* of *n* objects taken *r* at a time is the number of different arrangements of *r* items that can be taken from a larger group of *n* items. No item can occur more than once in an arrangement, and different orders of the same *r* items *are* counted separately.

Keys:	**Display:**	**Description:**
5 [INPUT]	`5.000:`	Enters the *n*-value. (The colon separates *n* and *r*.)
3 ■ [PROB] {Cn,r}	`10.0000`	Calculates combinations of 5 objects, 3 at a time.
5 [INPUT]	`5.000:`	Enters the *n*-value.
3 ■ [PROB] {Pn,r}	`60.0000`	Calculates permutations of 5 objects, 3 at a time.

Factorial. ■ [PROB] {n!} calculates the factorial of the number in the display. The number must be an integer in the range 0 through 253.

Hyperbolic Functions

The hyperbolic functions are listed below.

Hyperbolic Functions

Keys	Function
■ [HYP] [SIN]	Hyperbolic sine
■ [HYP] ■ [ASIN]	Inverse hyperbolic sine
■ [HYP] [COS]	Hyperbolic cosine
■ [HYP] ■ [ACOS]	Inverse hyperbolic cosine
■ [HYP] [TAN]	Hyperbolic tangent
■ [HYP] ■ [ATAN]	Inverse hyperbolic tangent

Keys:	Display:	Description:
5 ■ HYP SIN	74.2032	Hyperbolic sine.
540.25 ■ HYP ■ ACOS	6.9852	Inverse hyperbolic cosine.

Parts of Numbers

The functions in the PARTS menu perform number-altering operations.

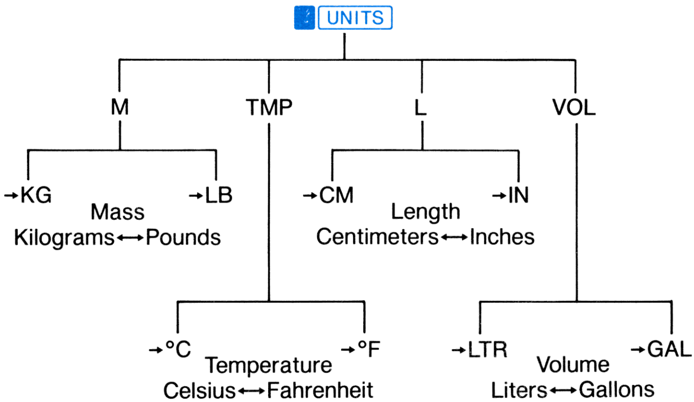
The PARTS Menu

Menu Key	Function
{IP}	Integer part of the number.
{FP}	Fractional part of the number (the number without its integer part).
{RN}	Rounds the number internally to the number of digits specified in the current FIX, SCI, or ENG display mode (no rounding occurs in ALL mode).
{ABS}	Absolute value of the number.

Keys:	Display:	Description:
■ DISP {FX} 4		Sets 4 decimal places.
12.3456789 =	12.3457	Enters a nine-digit number.
■ SHOW	12.3456789000	Shows full precision of number.
■ PARTS {RN} ■ SHOW	12.3457000000	Number is rounded internally.

Unit Conversions

The following illustration describes the UNITS menu and its unit-conversion functions.



Convert 100 pounds to kilograms.

Keys:	**Display:**	**Description:**
100 ■ UNITS {M} {→KG}	45.3592	Converts pounds to kilograms.

Convert 6 feet to centimeters.

6 [×] 12 [=]	72.0000	Converts 6 feet to inches.
■ UNITS {L} {→CM}	182.8800	Converts 72 inches to centimeters.

4

Base Conversions and Base Arithmetic

Switching Base Mode

The BASE menu ([BASE]) switches the calculator between four number-base modes—decimal, hexadecimal, octal, and binary. You can use the BASE modes to convert numbers from one base to another, and to perform arithmetic operations in any of the four bases.

Switching Base Mode

Keys	Description	Annunciator
[BASE] {DEC}	Switches to *decimal* (base 10) mode.	None
[BASE] {HX}	Switches to *hexadecimal* (base 16) mode. The top-row keys take on their letter assignments A through F.	**HEX**
[BASE] {OC}	Switches to *octal* (base 8) mode.	**OCT**
[BASE] {BN}	Switches to *binary* (base 2) mode. If the binary number is longer than 12 characters, the display shows the rightmost (least significant) 12 digits. Use {←} and {→} (the [√x] and [Σ+] keys) to view the rest of the number in 12-digit segments.	**BIN**

Switching base mode has these effects:

- The number in the display is converted to the new base. If you were in the middle of a calculation (for example, you had keyed in 4 [+] 5 [×] 3), all the numbers in the expression are converted to the new base.
- When you switch *from* decimal to another base, the *integer part* of the number is displayed in the new base. Internally, the 12-digit representation of the decimal number is preserved. When you switch back to decimal base, the full decimal number is displayed, rounded to the current display format. Numbers are *truncated* to integers internally only when they are used in an arithmetic operation in hexadecimal, octal, or binary base.
- Hexadecimal, octal, and binary numbers are right-justified in the display—that is, they are displayed as far to the right as possible.
- In hexadecimal, octal, and binary base, certain keys are deactivated. For example, the [8] and [9] keys do not function in octal base; keys [2] through [9] do not function in binary base. In addition, many of the HP-22S functions cannot be accessed.

Example: Converting Between Bases. The following keystrokes do a series of base conversions.

Convert 125_{10} to binary, octal, and hexadecimal numbers.

Keys:	**Display:**	**Description:**
125 ■ [BASE] {BN}	1111101	Switches to binary mode; 125_{10} = 1111101_2.
■ [BASE] {OC}	175	Switches to octal mode; 1111101_2 = 175_8.
■ [BASE] {HX}	7D	Sets HEX base; 175_8 = $7D_{16}$.
■ [BASE] {DEC}	125.0000	Restores decimal base.

Convert $24FF_{16}$ to binary base.

■ BASE {HX}	7D	Sets hexadecimal base.
24FF ■ BASE {BN}	010011111111	Converts $24FF_{16}$ to binary base and displays least significant 12 digits.
{←} (√x key)	10	Displays the digits to the left. The full number is 10010011111111_2.
{→} (Σ+ key)	010011111111	Displays the least significant digits.
■ BASE {DEC}	9,471.0000	Restores decimal base.

Representation of Numbers

Decimal numbers are stored internally as a 12-digit mantissa with a 3-digit exponent. When a number is converted from its decimal value to a different base, the integer part of the number is represented as a 36-bit, binary number. The leftmost (most significant) bit is the sign bit; it is set (1) for negative numbers.

Negative Numbers. The leftmost bit of the binary representation of a number is the sign bit. It is set to 1 for negative numbers. Negative numbers are represented internally as the 2's Complement of the positive binary number.

Keys:	Display:	Description:
8738 ■ BASE {HX}	2222	Converts $8{,}738_{10}$ to hexadecimal base.
+/-	FFFFFFDDDE	2's Complement.
■ BASE {DEC}	-8,738.0000	Negative decimal number.

Range of Hexadecimal, Octal, and Binary Numbers

The 36-bit word size determines the range of numbers that can be represented in hexadecimal, octal, or binary base, and the range of decimal numbers that can be converted to other bases.

Range of Numbers for Base Conversions

Base	Largest Positive Integer	Largest Negative Integer
DEC	34,359,738,367	-34,359,738,368
HEX	7FFFFFFFF	800000000
OCT	377777777777	400000000000
BIN	11111111111 111111111111 111111111111	100000000000 000000000000 000000000000

When you key in numbers in hexadecimal, octal, or binary base, digit entry halts if you attempt to key in too many digits. For example, if you attempt to key in a 10-digit hexadecimal number, digit entry halts after the ninth digit.

If the display contains a decimal number outside the allowed range, switching to another base displays `TOO BIG`.

Keys:	Display:	Description:
1 ■ E 20 ■ BASE {OC}	`TOO BIG`	1×10^{-20} is too large to be converted to octal base.
■ BASE {DEC}	`1.0000E20`	Restores decimal base.

When you are in the middle of a calculation, number(s) that are outside the conversion range are represented by the message TOO BIG.

3 ■ [E] 11 [−] 3 ■ [E] 8		$3E8_{10} = 11E1A300_{16}$.
■ [BASE] {HX}	- 11E1A300	
[◄]	TOO BIG-	3E11 is outside the base-conversion range.
■ [BASE] {DEC}	3.0000E11-	Restores decimal base.
[C]	0.0000	Clears the display.

Arithmetic Operations

The arithmetic operations [+], [−], [×], and [÷] can be performed in any base. You can also use [STO] and [RCL] to store and recall nondecimal numbers, and to do storage arithmetic.

All arithmetic operations use 2's Complement arithmetic. Operations with hexadecimal, octal, or binary base use integers only. When a division produces a remainder, only the integer portion of the number is retained.

If the result of an arithmetic operation in hexadecimal, octal, or binary base cannot be represented in 36 bits, the HP-22S displays the overflow warning, followed by the largest (or smallest) number possible.

Example: Arithmetic in Hexadecimal, Octal, and Binary Bases. Calculate $12F_{16} + E9A_{16}$.

Keys:	Display:	Description:
■ [BASE] {HX}		Sets hexadecimal base.
12F [+] E9A [=]	FC9	Adds hexadecimal numbers.

Calculate $7760_8 - 4326_8$.

■ [BASE] {OC}	7711	Switches to octal base ($FC9_{16} = 7711_8$).

7760 [−] 4326 [=]	3432	Calculates the result.

Calculate $100_8 \div 5_8$:

100 [÷] 5 [=]	14	Integer part of result.

Compare the previous result to the decimal division shown below:

100 [÷] 5 ■ [BASE] {DEC}	÷5.0000	Converts expression to decimal base.
[=]	12.8000	Division of $64_{10} \div 5_{10}$. ($100_8 = 64_{10}$).
■ [BASE] {OC}	14	Integer portion of 12.8_{10} in octal base.

Add $5A0_{16}$ plus 1001100_2.

■ [BASE] {HX} 5A0	5A0	Keys in hexadecimal number.
■ [BASE] {BN}	10110100000	Switches to binary base.
[+] 1001100 [=]	10111101100	Calculates result in binary base.

Arithmetic results that cannot be represented in 36 bits display an overflow warning and the largest positive or smallest negative number:

■ [BASE] {HX}	5EC	Switches to hexadecimal base.
5AAAAAAAA [×] 4 [=]	OVERFLOW 7FFFFFFFF	Displayed briefly. Largest positive number.
EBBBBBBBB [−] 6CCCCCCCC [=]	OVERFLOW 800000000	Smallest negative number.

5

Statistical Calculations

The [Σ+] and [Σ−] keys are used to enter and edit statistical data for one- and two-variable statistics. The data is accumulated in a set of statistical registers, which are automatically created when you enter the data. Once you've entered the data, you can use the STAT menu, which is accessed by pressing [STAT], to calculate:

- One-variable statistics: mean and standard deviation.
- Two-variable statistics: linear regression and linear estimation.
- Weighted mean.
- Summation statistics: n, Σx, Σy, Σx^2, Σy^2, and Σxy.

Entering Statistical Data

There is no limit on the number of values you can accumulate into the statistical registers. However, if [Σ+] causes the value of a statistical register to exceed $9.99999999999 \times 10^{499}$, the HP-22S displays a temporary overflow warning.

Entering Data for One-Variable Statistics

To enter data for one-variable statistics:

1. Clear any previously stored statistical data by pressing ■ [CLEAR] {Σ}.
2. Key in the first value and press [Σ+]. The HP-22S displays `n=1.0000`.
3. Continue entering values by keying in the numbers and pressing [Σ+]. The n-value is updated with each entry.

To recall a value to the display immediately after it has been entered, press ■ [LAST].

Entering Data for Two-Variable Statistics or Weighted Mean

To enter *x*,*y*-pairs of statistical data:

1. Clear any previously stored statistical data by pressing ■ [CLEAR] {Σ}.
2. Key in the first *x*-value and press [INPUT]. The HP-22S displays the *x*-value followed by a colon (:).
3. Key in the corresponding *y*-value and press [Σ+]. The HP-22S displays `n=1.0000`.
4. Continue entering *x*,*y*-pairs. The *n*-value is updated with each entry.

To enter data for calculating the weighted mean, enter each data value as *x*, and its corresponding weight as *y*.

Correcting Statistical Data

If incorrect data has been entered by pressing [Σ+], it can be deleted using [Σ−]. Then, the correct value is added using [Σ+]. If one value of an *x*,*y*-pair is incorrect, you *must* delete and then re-enter both values.

To correct statistical data:

1. Key in the *x*-value to be deleted. If the data consists of *x*,*y*-pairs, press [INPUT] and then key in the *y*-value.
2. Press [Σ−] to delete the value(s).* The *n*-value is decreased by 1.
3. Enter the correct value or *x*,*y*-pair using [Σ+].

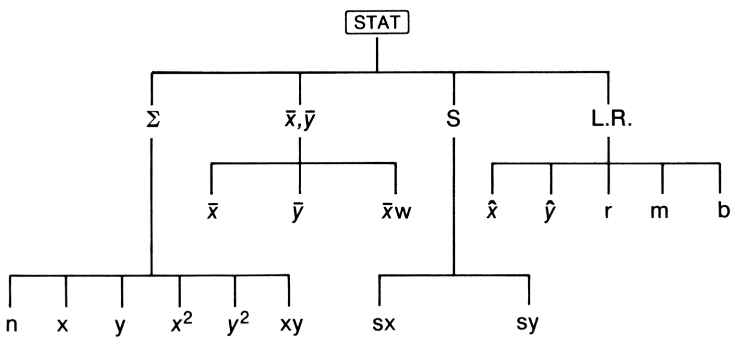
* [Σ−] does not delete rounding errors that may occur when incorrect values are entered into the statistical registers. Thus, subsequent results for corrected data may be different than for data that was entered correctly without having to use [Σ−]. However, the difference will not be serious unless the incorrect data has a very large magnitude compared with the correct values; in this case, you may want to clear the statistical registers and re-enter all the data.

Clearing Statistical Data

You should clear the statistical registers before entering new data, or when you no longer need the data and want to reclaim the memory it uses. To clear the statistical registers, press ■ CLEAR {Σ}.

Statistical Calculations

The STAT menu, displayed by pressing STAT, provides the statistical functions.



The STAT Menu and Statistical Functions

Menu Key	Description
{Σ}	Displays menu of summation statistics:
{n}	The number of data points entered.
{x}	Sum of the *x*-values.
{y}	Sum of the *y*-values.
{x²}	Sum of the squares of the *x*-values.
{y²}	Sum of the squares of the *y*-values.
{xy}	Sum of the products of the *x*- and *y*-values.

The STAT Menu and Statistical Functions (Continued)

Menu Key	Description
{ $\bar{x}$,$\bar{y}$ }	Displays menu for means:
{ $\bar{x}$ }	Arithmetic mean (average) of the x-values.
{ $\bar{y}$ }	Arithmetic mean (average) of the y-values.
{ $\bar{x}$w }	Weighted mean of the x-values weighted according to the y-values.
{ s }	Displays menu for sample standard deviation:*
{ sx }	Standard deviation of the x-values.
{ sy }	Standard deviation of the y-values.
{ L.R. }	Displays menu for linear regression and linear estimation:
{ $\hat{x}$ }	Estimate of x for a given value of y.
{ $\hat{y}$ }	Estimate of y for a given value of x.
{ r }	Correlation coefficient.†
{ m }	Slope of the calculated line.
{ b }	y-intercept of the calculated line.

* The standard deviation is a measure of how dispersed the numbers are about the mean. The HP-22S calculates the *sample standard deviation*, which assumes the data is a sampling of a larger, complete set of data. If the data constitutes the entire population of data, the *true population*, see page 64, "Calculating the Population Standard Deviation."

† The correlation coefficient is a number in the range −1 through +1 that measures how closely the data fits the calculated line. A value of +1 indicates a perfect positive correlation, −1 indicates a perfect negative correlation. A value close to 0 indicates the curve is a poor fit.

One-Variable Statistical Calculations

If you enter a list of single numbers, they are stored as x-values. You can then calculate:

- Mean and standard deviation of x ($\bar{x}$ and sx).
- Summations: n, Σx, and Σx^2.

Example: Calculating the Mean and Standard Deviation. Production supervisor May Kitt wants to determine how long a certain process takes. She randomly picks six people, observes them as they carry out the process, and records the number of minutes required:

15.5	9.25	10.0
12.5	12.0	8.5

Calculate the mean and standard deviation of the times.

Keys:	Display:	Description:
■ [CLEAR] {Σ}		Clears the statistical registers.
15.5 [Σ+]	n=1.0000	Enters the first time.
9.25 [Σ+] 10 [Σ+] 12.5 [Σ+] 12 [Σ+] 8.5 [Σ+]	n=6.0000	Enters the remaining data.
[STAT] {$\bar{x}$,$\bar{y}$} {$\bar{x}$}	$\bar{x}$=11.2917	Calculates the mean.
[STAT] {s} {sx}	sx=2.5808	Calculates the standard deviation.

Calculating the Population Standard Deviation

The standard deviations calculated by {sx} and {sy} are the sample standard deviations. They assume that the data is a sampling of a larger, complete set of data. If the data constitutes the entire population of data, the *true population standard deviation* can be computed by calculating the mean of the original data, adding the mean to the statistical data using [Σ+], and then calculating the standard deviation.

Example: Population Standard Deviation. Grandma Hinckle has four grown sons with heights of 170, 173, 174, and 180 cm. Find the mean and standard deviations of their heights.

Keys:	Display:	Description:
■ [CLEAR] {Σ}		Clears the statistics registers.
170 [Σ+] 173 [Σ+] 174 [Σ+] 180 [Σ+]	n=4.0000	Enters the data.
[STAT] {x̄,ȳ} {x̄}	x̄=174.2500	Calculates the mean.
[Σ+]	n=5.0000	Adds the mean to the data.
[STAT] {s} {sx}	sx=3.6315	Calculates the population standard deviation.

Linear Regression and Estimation

Linear regression is a statistical method for finding a straight line that best fits a set of *x,y*-data. There must be at least two *x,y*-pairs. The straight line provides a relationship between the *x*- and *y*-variables.

Linear Regression. To do a linear regression calculation:

1. Enter the *x,y*-data using the instructions on page 61.
2. Press [STAT], then {L.R.}.
3. Press:
   - {r} to calculate the correlation coefficient.
   - {m} to calculate the slope of the line.
   - {b} to calculate the *y*-intercept.

The straight line calculated by linear regression can be used to estimate a *y*-value for a given *x*-value, or vice versa.

Linear Estimation. To do linear estimation calculations:

1. Enter the *x,y*-data using the instructions on page 61.
2. If you want to see the slope, *y*-intercept, and/or correlation coefficient for the linear regression fit, you can do so by pressing [STAT] {L.R.} {m}, [STAT] {L.R.} {b}, and [STAT] {L.R.} {r}.
3. Key in the known *x*-value or *y*-value.
4. Press [STAT] {L.R.}. Then:
   - To estimate *x* for the given *y*, press {$\hat{x}$}.
   - To estimate *y* for the given *x*, press {$\hat{y}$}.

See chapter 8 for an alternative way of doing linear estimation using [EVAL].

Example: Linear Regression and Estimation. Part 1. After receiving C grades in their first statistics exam, four students sought help from Paul J. McTutor. Because Paul loves numbers, he recorded the following data based on the results of their second exam:

X Hours of tutoring	1	3	4	6
Y Grade	64	88	76	98

Calculate the correlation coefficient and *y*-intercept for the data.

Keys:	**Display:**	**Description:**
■ [CLEAR] {Σ}		Clears the statistical registers.
1 [INPUT] 64 [Σ+] 3 [INPUT] 88 [Σ+] 4 [INPUT] 76 [Σ+] 6 [INPUT] 98 [Σ+]	n=4.0000	Enters the *x,y*-data.
[STAT] {L.R.} {r}	r=0.8587	Calculates the correlation coefficient.
[STAT] {L.R.} {b}	b=60.2308	Calculates the *y*-intercept.

Part 2: Calculate the mean of the four exam grades.

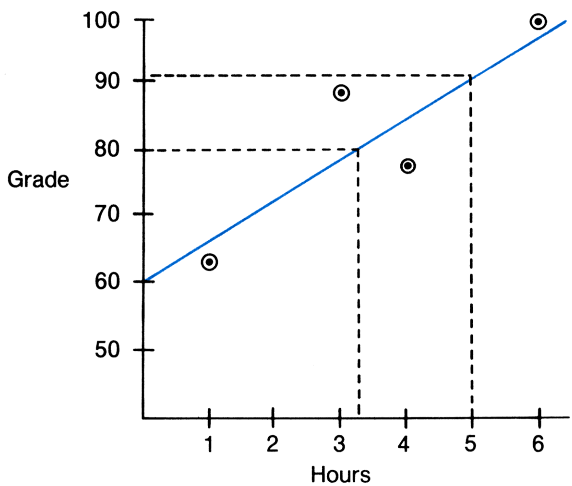
STAT {$\bar{x}$,$\bar{y}$} {$\bar{y}$}	$\bar{y}$=81.5000	Calculates the mean.

Part 3: Estimate the number of hours of tutoring necessary to achieve a grade of 80.

80 STAT {L.R.} {$\hat{x}$}	$\hat{x}$=3.2532	Calculates estimate of x for $y = 80$.

Part 4: Estimate the grade after 5 hours of tutoring.

5 STAT {L.R.} {$\hat{y}$}	$\hat{y}$=90.6154	Calculates estimate of y for $x = 5$.



Weighted Mean

The following procedure calculates the weighted mean of data points $x_1, x_2, \ldots x_n$ occurring with weights $y_1, y_2, \ldots y_n$. The weights can be integer or non-integer values.

1. Use [Σ+] to enter the data as x,y-pairs. The y-values are the weights of the x-values.
2. Press [STAT] {x̄,ȳ} {x̄w}.

Example: Weighted Mean. Your manufacturing company purchases a certain part four times a year. Last year's purchases were:

Price per part	$4.25	$4.60	$4.70	$4.10
Number of Parts	250	800	900	1000

Calculate the weighted mean of the price data.

Keys:	**Display:**	**Description:**
■ [CLEAR] {Σ}		Clears the statistical registers.
4.25 [INPUT] 250 [Σ+] 4.6 [INPUT] 800 [Σ+] 4.7 [INPUT] 900 [Σ+] 4.1 [INPUT] 1000 [Σ+]	n=4.0000	Enters the data and their weights.
[STAT] {x̄,ȳ} {x̄w}	x̄w=4.4314	Calculates weighted mean.

Summation Statistics

The STAT menu includes {Σ} for calculating n, Σx, Σy, Σx^2, Σy^2, and Σxy.

Example: Summation Statistics. Calculate Σx and Σx^2 for the following values of x: 2.345, 3.456, 4.567.

Keys:	Display:	Description:
■ [CLEAR] {Σ}		Clears the statistical registers.
2.345 [Σ+]		Enters the data.
3.456 [Σ+]		
4.567 [Σ+]	n=3.0000	
[STAT] {Σ} {x}	Σx=10.3680	Calculates Σx.
[STAT] {Σ} {x²}	Σx²=38.3005	Calculates Σx^2.

6

Evaluating and Solving Equations

An Example

[EVAL] and [SOLVE] allow you to do calculations involving variables. For example, suppose you frequently need to determine the volume of a straight section of pipe. The equation is:

$$V = .25\,\pi\, d^2\, l$$

where d is the inside diameter of the pipe, and l is its length. You could key in the calculation over and over; for example, .25 [×] ■[π] [×] 2.5 ■[x^2] [×] 16 calculates the volume of 16 inches of 2½-inch pipe. However, storing the equation saves keystrokes and lets you use the calculator to "remember" the relationship between diameter, length, and volume.

Keys:	Display:	Description:
■[EQUATIONS]		Displays the list of equations.

If necessary, press [▼] until the HP-22S displays TYPE NEW EQN. Then:

[STO] V [=]	V=	[STO] V types V.
.25 [×] ■[π] [×]	V=.25×π×	■[π] types π.
[STO] D [y^x] 2	V=.25×π×D^2	[y^x] types ^.

[×] [STO] L	=.25×π×D^2×L	V scrolls off left side of the display.
[INPUT]	V=.25×π×D^2×L	[INPUT] stores equation.
[EVAL]	D?*value*	Prompts for (requests) *D*; *value* is the current value of *D*.
2.5 [INPUT]	D=2.5000 L?*value*	Stores *D*, prompts for *L*.
16 [INPUT]	L=16.0000 V=78.5398	Stores *L*, calculates *V* in cubic inches.

To calculate *V*, the HP-22S *evaluates* the right side of the equation. [EVAL] automates keystrokes you would otherwise have to do repeatedly for each calculation.

[SOLVE] lets you solve equations for any variable without rearranging the equation. For example, you might wonder what length of 2½-inch pipe holds 40 cubic inches of water. Assuming you've just completed the previous keystrokes:

Keys:	**Display:**	**Description:**
■ [SOLVE]	D L V	Menu for selecting the unknown variable.
{L}	V?78.5398	Selects *L*, prompts for *V*.
40 [INPUT]	V=40.0000 D?2.5000	Stores *V*, prompts for *D*.
[INPUT]	D=2.5000 SOLVING L=8.1487	Retains previous *D*, calculates *L*.

Introduction to [EVAL] and [SOLVE] Functions

The following keys provide the ability to do calculations with equations:

■ [EQUATIONS] Pressing ■ [EQUATIONS] displays the list of equations, which stores equations that you enter. Press [▼] or ■ [▲] to roll through the list. The number of equations you can enter is limited only by the amount of available memory. You can also enter algebraic expressions. (Expressions don't have two sides separated by an "equals" sign). You can edit and clear entries in the equation list.

■ [LIBRARY] Pressing ■ [LIBRARY] displays the equation library. The library is a list of 16 permanent, built-in equations. Press [▼] or ■ [▲] to roll through the list. You cannot edit or clear library equations. The library equations are described in chapter 7.

[EVAL] [EVAL] calculates the value of the "unknown" variable (the variable whose value you seek) when the equation has the form:

unknown variable = *algebraic expression*

The unknown must appear by itself on the left side of the equation. [EVAL] can also be used to evaluate expressions.

■ [SOLVE] [SOLVE] lets you solve the equation for any variable; the unknown variable does not have to appear by itself, on the left side of the equation. Thus, [SOLVE] saves you the trouble of having to rearrange the equation yourself.

■ [EDIT] Allows you to change an equation after it has been entered into the list of equations.

Entering Your Own Equations

To enter an equation or expression into the list of equations:

1. Make sure the equation or expression follows the syntax rules (see "The Syntax of Equations" on page 78).
2. Press ■ [EQUATIONS].
3. If necessary, press [▼] until the HP-22S displays TYPE NEW EQN.
4. Type the equation.
   - To type a variable, press [STO] or [RCL] to give the keys their letter assignments (the **A..Z** annunciator comes on). Then, press a letter key.
   - To type an operator, press an operator key—[+], [−], [×], [÷], or [y^x] (^).
   - To type a function, use the same keystrokes you would use to execute the function in a calculation (see the tables on pages 80 through 83). For example:

To type:	**Press:**
SIN(A)	[SIN] [STO] A [)]
ACOSH(A÷B)	■ [HYP] ■ [ACOS] [RCL] A [÷] [STO] B [)]
SIN(ACOS(A))	[SIN] ■ [ACOS] [STO] A [)] [)]
COMB(T:Q)	■ [PROB] {Cn,r} [STO] T ■ [:] [RCL] Q [)]

5. Do **a**, **b**, or **c**:
   - **a.** Press [INPUT] to enter the equation.
   - **b.** Press [EVAL] to enter the equation and evaluate it.
   - **c.** Press ■ [SOLVE] to enter the equation and solve it for any variable.

Viewing and Selecting Equations

Both [EVAL] and [SOLVE] do calculations using the equation that was displayed last before you pressed [EVAL] or ■[SOLVE]. To select a different equation, press ■[EQUATIONS] or ■[LIBRARY]. The ▲ and ▼ annunciators come on when there are other equations in the list. Press [▼] or ■[▲] to "roll" through the list.

Each time you return to the equation list or library, you will be positioned where you were the last time you used the list.

Viewing Long Equations. When an equation is too long to fit in the display, the scrolling annunciators (⟶ and/or ⟵) indicate more characters to the right or left. Hold down the keys beneath the pointers (⬇) to scroll through the equation.

Editing and Clearing Equations

Equations in the list of equations can be edited and cleared. You cannot edit or clear library equations.

Editing an Equation. To edit the selected equation, press ■[EDIT]. The cursor is positioned at the end of the equation. If necessary, use [◀] to backspace to the appropriate character. Type the rest of the equation and press [INPUT].

If you press [EDIT] accidently, press [C] immediately (before you've pressed any other keys) to restore the previous display.

Clearing an Equation. To clear an individual equation, display it and press ■[CLEAR] {Y}.

Clearing All Equations. To clear all the equations in the list of equations, cancel the equation list or library list. (The HP–22S will *not* be displaying, an equation). Press ■[CLEAR] to display the CLEAR menu, then {EQ} {Y}.

Instructions for Using [EVAL]

Use [EVAL] when the unknown variable appears only once in the equation, by itself on the left side of the equation. You can also use [EVAL] to evaluate expressions. For example, you can use [EVAL]:

To calculate *F* in the equation:	F=M×A
To calculate *E* in the equation:	E=.5×M×V^2
To calculate *S** in the equation:	S=S×(1+I)^N
To evaluate the expression:	T^2÷(P+12)

To evaluate an equation:

1. Press [EVAL].†
2. The HP-22S prompts (requests values) for each variable on the right side of the equation by displaying *letter?value*, where *value* is the current value of the variable. Respond to each prompt:
   - To retain the current value, press [INPUT].
   - To store a different value, key in a number (use [+/-] for negative numbers) or an algebraic expression (for example, 13 [×] 6 [√x]) and press [INPUT].
3. When you've responded to all the prompts, the HP-22S evaluates the equation or expression and displays the answer.

When it evaluates expressions, [EVAL] prompts for every variable and calculates the value of the expression. The result is labeled EXPR.

* The equation calculates a new value for *S* using a value for *S* that you input.

† If an equation is not in the form *unknown variable* = *algebraic expression*, the HP-22S automatically switches to [SOLVE].

Example: Evaluating an Expression. Evaluate the expression:

$$e^x + y + z$$

for $x = 1$, $y = 2$, and $z = 2.5$.

Keys:	**Display:**	**Description:**
■ [EQUATIONS]		

If necessary, press [▼] until the HP-22S displays TYPE NEW EQN. Then:

[e^x] [STO] X [+] [STO] Y [+] [STO] Z [)]	EXP(X+Y+Z)	Types the expression.
[EVAL]	X?*value*	Prompts for X.
1 [INPUT]	Y?*value*	Stores *X*, prompts for *Y*.
2 [INPUT]	Z?*value*	Stores *Y*, prompts for *Z*.
2.5 [INPUT]	EXPR=244.6919	Evaluates the expression.

Hints for Responding to Prompts

Calculating Input Values. You can do calculations in response to prompts. For example, in response to the prompt A?*value*, pressing 7 [+] 4 [$\sqrt{x}$] [INPUT] stores 9 in *A*. Similarly, in response to B?*value*, pressing 5 ■ [:] 8 ■ [%CHG] [INPUT] stores 60 in B. (Notice that ■ [:] is used to display the colon to separate the two arguments of the percent change function.)

Viewing Briefly-Displayed Information. Two situations in [EVAL] and [SOLVE] cause information to be displayed briefly:

- **Newly-Assigned Values.** After you've pressed [INPUT] in response to a prompt, the HP-22S temporarily displays *letter=new value* before proceeding. To lengthen the viewing time for the new value, hold down the [INPUT] key.
- **Labels and Long Numbers.** If a variable and its value are too long to fit in the display, the letter is displayed briefly. For example, if the current value for *A* is 1,234,567,891.23, the prompt for *A* is:

`A?`	Displayed briefly.
`1,234,567,891.23`	HP-22S awaits input.

  To see the first part of the prompt again, press ■ [SHOW].

Instructions for Using [SOLVE]

Use [SOLVE] when the unknown variable is *not* by itself on the left side of the equation. To solve for a variable:

1. **Optional:** Enter your own guesses for the answer. (See "Entering Your Own Initial Guesses" on page 87.)
2. Press ■ [SOLVE].
3. If the equation has more than one variable, the HP-22S displays a menu of all the variables in the equation. Select the unknown variable by pressing the appropriate menu key. (For equations with more than six variables, use the menu key {→}, if necessary, to display the rest of the variables.)
4. The HP-22S prompts (requests values) for each known variable by displaying *letter?value*, where *value* is the current value of the variable. Respond to each prompt:
   - To retain the current value, press [INPUT].
   - To store a different value, key in a number (use [+/-] for negative numbers) or an algebraic expression (for example, 13 [×] 6 [√x]) and press [INPUT].

5. When you've stored all the known values, the HP-22S displays SOLVING. For some complicated calculations, the computation may take several minutes. If [SOLVE] calculates an answer, it displays the labeled result.

If, for some reason, [SOLVE] is unable to find a solution, it displays an appropriate message to help you diagnose the situation. If necessary, refer to "How [SOLVE] Works" on page 87, or to appendix B, for additional information about [SOLVE].

The Syntax of Equations

Equations and expressions must follow certain syntax rules:

- Equation length is limited only by the amount of available memory.
- Equations can contain any of the 26 variables, *A* through Z. There is no limit on how many times a particular variable appears in an equation.
- Use ■[E] to enter exponential numbers.
- Equations can use any of the functions listed in the tables on pages 80 through 83. The arguments—the number(s) acted upon—are enclosed in parentheses.
- Algebraic expressions are interpreted according to these operator priorities:

: (separating arguments in functions)	Highest priority
Expressions inside parentheses	↓
Functions (for example, SIN, ABS, PERM)	↓
[y^x]	↓
[×] [÷]	↓
[+] [−]	Lowest priority

For example:

`A×B^3=C` is interpreted as $A \times B^3 = C$. To raise $A \times B$ to the 3rd power, enter `(A×B)^3=C`.

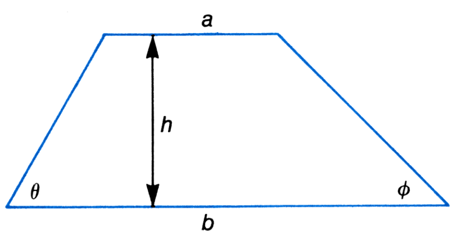
`A+B÷C=12` is interpreted as $A + (B \div C) = 12$. To divide the sum of $A + B$ by C, enter `(A+B)÷C=12`.

In interpreting `CHG(T+12:A-6)^2`, the Solver evaluates the arguments $T + 12$ and $A - 6$, computes the value of the function, and then squares the function value.

- You cannot use parentheses for implied multiplication. For example, the expression $P(1-F)$ must be entered as `P×(1-F)`, with the `×` operator inserted between `P` and the parenthesis.

Example: Using the Syntax Rules To Write an Equation. The following equation calculates the perimeter of a trapezoid. The equation is written as it might appear in a book:

$$Perimeter = a + b + h\left(\frac{1}{\sin\theta} + \frac{1}{\sin\phi}\right)$$



The following equation obeys the syntax rules for HP-22S equations:

Parentheses used to group terms

`P=A+B+H×(1÷SIN(T)+1÷SIN(F))`

Single letter name

No implied multiplication

Division is done before addition

The next equation also obeys the syntax rules. This equation uses the *inverse* function, INV (typed by [1/x]) instead of 1÷. Notice that the sine (SIN) function is "nested" (located inside) the INV function:

P=A+B+H×(INV(SIN(T))+INV(SIN(F)))

Equation Functions

You can use most of the HP-22S numeric functions in equations. If the function has arguments, they are enclosed in parentheses; functions requiring two arguments use a colon (:) to separate the two arguments. (Arguments are the numbers acted upon by functions. For example, X is the argument in SIN(X), which calculates the sine of X.)

The arguments of functions can be constants, variables, algebraic expressions, and other functions.

The functions are grouped into three categories:

- General math functions.
- Statistics functions.
- Unit conversion functions.

General Math Functions

Function	Description	Typing Aid
ABS(x)	Absolute value.	■ [PARTS] {ABS}
ACOS(x)	Arc cosine.*	■ [ACOS]
ACOSH(x)	Hyperbolic arc cosine.	■ [HYP] ■ [ACOS]
ALOG(x)	Common (base 10) antilogarithm; 10^x.	■ [10^x]
ASIN(x)	Arc sine.*	■ [ASIN]
ASINH(x)	Hyperbolic arc sine.	■ [HYP] ■ [ASIN]
ATAN(x)	Arc tangent.*	■ [ATAN]
ATANH(x)	Hyperbolic arc tangent.	■ [HYP] ■ [ATAN]

* Uses the current angular mode—Degrees or Radians.

General Math Functions (Continued)

Function	Description	Typing Aid
CHG(n_1:n_2)	Percent change between n_1 and n_2.	■ %CHG
COMB(n:r)	Number of combinations of n items taken r at a time.	■ PROB {Cn,r}
COS(x)	Cosine.*	COS
COSH(x)	Hyperbolic cosine.	■ HYP COS
DEG(x)	Converts x in radians to decimal degrees.	■ D↔RAD {DEG}
EXP(x)	Natural antilogarithm; e^x.	e^x
FACT(x)	Factorial; x is an integer $\geqslant$ 0.	■ PROB {n!}
FP(x)	Fractional part.	■ PARTS {FP}
HMS(x)	Converts x in decimal hours (degrees) to HH.MMSS (DD.MMSS) format.	■ H↔HMS {→HMS}
HR(x)	Converts x in H.MMSS (D.MMSS) format to decimal format.	■ H↔HMS {→HR}
INV(x)	Reciprocal, $1/x$.	1/x
IP(x)	Integer part.	■ PARTS {IP}
LN(x)	Natural (base e) log.	LN
LOG(x)	Common (base 10) log of x.	■ LOG
PERM(n:r)	Permutations of n items taken r at a time.	■ PROB {P n,r}
π	π; 3.14159265359 (12 digits).	■ π
RAD(x)	Converts x in decimal degrees to radians.	■ D↔RAD {RAD}
r(x:y)	*Radius* polar coordinate for (x,y) rectangular coordinates.*†	■ RADIUS
RN(x)	x rounded to the number of decimal places in the current display format.	■ PARTS {RN}
SIN(x)	Sine.*	SIN
SINH(x)	Hyperbolic sine.	■ HYP SIN
SQ(x)	x^2.	■ x^2

* Uses the current angular mode—Degrees or Radians.

† The function does *not* use the coordinate conversion registers.

General Math Functions (Continued)

Function	Description	Typing Aid
SQRT(*x*)	$\sqrt{x}$.	[√x]
TAN(*x*)	Tangent.*	[TAN]
TANH(*x*)	Hyperbolic tangent.	■ [HYP] [TAN]
θ(*x*:*y*)	θ polar coordinate for (*x*,*y*) rectangular coordinates.*†	■ [ANGLE]
x(*r*:θ)	*x*-coordinate of polar coordinates.*†	■ [xCOORD]
y(*r*:θ)	*y*-coordinate of polar coordinates.*†	■ [yCOORD]

* Uses the current angular mode—Degrees or Radians.

† The function does *not* use the coordinate conversion registers.

Statistical Functions*

Function	Description	Typing Aid
b	*y*-intercept of the line calculated by linear regression.	[STAT] {L.R.} {b}
m	Slope of the line calculated by linear regression.	[STAT] {L.R.} {m}
n	Number of *x* entries or number of *x*,*y*-pairs.	[STAT] {Σ} {n}
r	Correlation coefficient between the data and the line calculated by linear regression.	[STAT] {L.R.} {r}
sx	Standard deviation of the *x*-values.	[STAT] {s} {sx}
sy	Standard deviation of the *y*-values.	[STAT] {s} {sy}
Σx	Sum of the *x*-values.	[STAT] {Σ} {x}
Σx^2	Sum of the squares of the *x*-values.	[STAT] {Σ} {x²}
Σxy	Sum of the products of the *x*- and *y*-values.	[STAT] {Σ} {xy}

* The statistical functions use the data stored in the statistical registers.

Statistical Functions* (Continued)

Function	Description	Typing Aid
Σy	Sum of the *y*-values.	[STAT] {Σ} {y}
Σy^2	Sum of the squares of the *y*-values.	[STAT] {Σ} {y²}
$\bar{x}$	Arithmetic mean (average) of the *x*-values.	[STAT] {x̄,ȳ} {x̄}
$\hat{x}(y)$	Estimates the *x*-value for the given value of *y*, using the line calculated by linear regression.	[STAT] {L.R.} {x̂}
$\bar{x}$w	Weighted mean of the *x*-values weighted according to the *y*-values.	[STAT] {x̄,ȳ} {x̄w}
$\bar{y}$	Arithmetic mean (average) of the *y*-values.	[STAT] {x̄,ȳ} {ȳ}
$\hat{y}(x)$	Estimates the *y*-value for the given value of *x*, using the line calculated by linear regression.	[STAT] {L.R.} {ŷ}

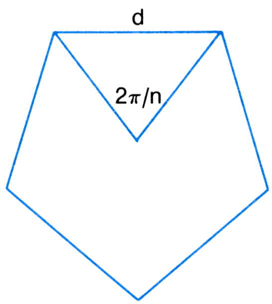
* The statistical functions use the data stored in the statistical registers.

Unit-Conversion Functions

Function	Conversion	Typing Aid
°C(*x*)	Degrees Fahrenheit to degrees Celsius.	■ [UNITS] {TMP} {→°C}
CM(*x*)	Inches to centimeters.	■ [UNITS] {L} {→CM}
°F(*x*)	Degrees Celsius to degres Fahrenheit.	■ [UNITS] {TMP} {→°F}
GAL(*x*)	Liters to U.S. gallons.	■ [UNITS] {VOL} {→GAL}
IN(*x*)	Centimeters to inches.	■ [UNITS] {L} {→IN}
KG(*x*)	Pounds to kilograms.	■ [UNITS] {M} {→KG}
LTR(*x*)	U.S. gallons to liters.	■ [UNITS] {VOL} {→LTR}
LB(*x*)	Kilograms to pounds.	■ [UNITS] {M} {→LB}

Example: Area of a Polygon. The equation for the area of a regular polygon with n sides of length d equals:

$$Area = \frac{1}{4}\, nd^2 \frac{\cos(\pi/n)}{\sin(\pi/n)}$$



The equation is entered into the list of equations as:

A=N×D^2×COS(π÷N)÷(4×SIN(π÷N))

Calculate the area of a pentagon with equal sides 6 centimeters long.

Keys:	**Display:**	**Description:**
■ [EQUATIONS]		Displays the equation list.

If necessary, press [▼] until the HP-22S displays TYPE NEW EQN. Type the equation,* then:

[EVAL]	N?*value*	Prompts for *N*.
5 [INPUT]	D?*value*	Stores *N*, prompts for *D*.
6 [INPUT]	A=4,103.3434	Calculates the area.

* The keystrokes for typing the equation are [STO] A [=] [STO] N [×] [STO] D [y^x] 2 [×] [COS] ■ [π] [÷] [STO] N [)] [÷] [(] 4 [×] [SIN] ■ [π] [÷] [STO] N [)] [)].

Example: An Equation for Linear Estimation. The following equation uses the *x*,*y*-data in the statistics registers to estimate *y* for various values of *x*. (Although this calculation can be done using the STAT menu, the equation allows you to do repetitive estimation calculations with fewer keystrokes.)

`Y=ŷ(X)`

Use the following *x*,*y*-data to estimate *y* for *x* = 2.5, 3.5, and 4.5

X	2	1	3	5	5	4
Y	140	92	110	226.5	289	220

Keys:	**Display:**	**Description:**
■ [EQUATIONS]		Displays the equation list.

If necessary, press [▼] until the HP-22S displays `TYPE NEW EQN`. Type the equation* and press [INPUT]. Then:

Keys:	**Display:**	**Description:**
[C] ■ [CLEAR] {Σ}		Clears the statistics registers.
2 [INPUT] 140 [Σ+] 1 [INPUT] 92 [Σ+] 3 [INPUT] 110 [Σ+] 5 [INPUT] 226.5 [Σ+] 5 [INPUT] 289 [Σ+] 4 [INPUT] 220 [Σ+]	`n=6.0000`	Enters the *x*,*y*-data.
[EVAL] 2.5 [INPUT]	`Y=144.0938`	Estimates *y* for *x*=2.5.
[EVAL] 3.5 [INPUT]	`Y=186.6813`	Estimates *y* for *x*=3.5.
[EVAL] 4.5 [INPUT]	`Y=229.2688`	Estimates *y* for *x*=4.5.

* The keytrokes for typing the equation are [STO] Y [=] [STAT] {L.R.} {ŷ} [STO] X [)].

Example: Converting Between Feet and Meters. Part 1: Write an equation that converts between feet and meters.

Since:

$$\text{Number of inches} = \text{Number of feet} \times 12$$

$$\text{Number of centimeters} = \text{Number of meters} \times 100$$

The equation is:

`IN(M×100)=F×12`

Part 2: Convert 22 feet to meters.

Keys:	Display:	Description:
■ [EQUATIONS]		

If necessary, press [▼] until the HP-22S displays `TYPE NEW EQN`. Type the equation* and press [INPUT]. Then:

Keys:	Display:	Description:
■ [SOLVE] {M}	`F?`*value*	Selects *M*, prompts for feet.
22 [INPUT]	`M=6.7056`	Calculates meters.

Part 3: Convert 0.2 kilometers to feet.

Keys:	Display:	Description:
■ [SOLVE] {F}	`M?6.7056`	Selects *F*, prompts for meters.
.2 [×] 1000 [INPUT]	`M=200.0000` `F=656.1680`	Calculates, stores *M*. Calculates feet.

* The keystrokes for typing the equation are: ■ [UNITS] {L} {→IN} [STO] M [×] 100 [)] [=] [STO] F [×] 12.

How [SOLVE] Works

[SOLVE] uses an iterative (repetitive) technique to solve for the unknown. The technique starts by substituting two initial guesses for the unknown into the equation. Based on its results with those guesses, [SOLVE] generates another, better guess. Through successive iterations, [SOLVE] finds a value that sets the left side of the equation equal to the right side.

Some equations are more difficult to solve than others. In some cases, you will have to enter initial guesses yourself in order to find the solution (see "Entering Your Own Initial Guesses" below.) If [SOLVE] is unable to find a solution, it displays an error message.

See appendix B for additional information about [SOLVE].

Entering Your Own Initial Guesses

The two initial guesses that [SOLVE] uses are:

- The number currently stored in the unknown.
- The last number that was in the display before you pressed ■ [SOLVE].

Since [SOLVE] starts its search for the answer in the range between the two guesses, entering your own guesses has the following advantages:

- Good guesses can reduce the time required to find a solution.
- If there is more than one solution, the guesses can help select the desired answer. For example, the equation of motion in the library:

  `X=S+V+.5×A×T^2`

  can have two solutions for *T*. You can calculate either answer by entering appropriate guesses.
- If an equation does not allow certain values for the unknown, guesses can help you avoid those values. For example, the equation:

  `Y=T+LOG(X)`

  does not allow values $X \leq 0$. Appropriate guesses can help [SOLVE] avoid the math errors `LOG(0)` and `LOG(NEG)`.

To enter your guess(es):

1. If the HP-22S is displaying the equation, press [C].
2. Store a guess in the unknown variable. For example, if the unknown is X, 2 [STO] X stores 2 as a guess.
3. If you want to use a second guess, key in the value. (If you don't do this step, there is only one guess, since the variable and display contain the same number.)
4. Proceed with step 2 under "Instructions for Using [SOLVE]" on page 77.

Example: Using Guesses. Part 1: How long does it take an object with an initial velocity of 10 meters/second accelerating at 2 meters/second^2 to travel a distance of 1000 meters? (Use the library equation X=S+V×T+.5×A×T^2.)

Keys:	**Display:**	**Description:**
■ [LIBRARY]		Displays the library.

If necessary, press [▼] until the HP-22S displays the beginning of the equation. Then:

Keys:	**Display:**	**Description:**
[C] 10 [STO] T	T=10.0000	Enters one guess.
50 ■ [SOLVE]	A S T V X	Enters second guess.
{T}	X?*value*	Selects *T*, prompts for X.
1000 [INPUT]	S?*value*	Stores X, prompts for *S*.
0 [INPUT]	V?*value*	Stores initial position of 0, prompts for *V*.
10 [INPUT]	A?*value*	Stores *V*, prompts for *A*.
2 [INPUT]	T=27.0156	Solves for *T*.

Part 2: Watch what happens if you use −10 and −50 as guesses:

Keys:	Display:	Description:
10 [+/−] [STO] T 50 [+/−] [■] [SOLVE]	`A S T V X`	Enters guesses.

{T}
[INPUT]
[INPUT]
[INPUT]
[INPUT]
	`X?1,000.00`
	`S?0.0000`
	`V?10.0000`
	`A?2.0000`
	`T=-37.0156`
		Retains previous values for *X*, *S*, *V*, and *A*; calculates *T*.

The negative value for *T* is not physically meaningful for this problem.

Halting and Restarting the [SOLVE] Iteration

To halt the iterative search, press [C] while the HP-22S is displaying `SOLVING`. The HP-22S displays `INTERRUPTED`. Press [RCL] *unknown variable* to see the best estimate [SOLVE] as found so far. To restart the search from where it left off, display the best estimate (it becomes your initial guess) and solve the equation again.

If the value stored in the unknown leads you to believe that [SOLVE] is not proceeding towards a reasonable answer, you can enter new guesses and solve again.

When [SOLVE] Can't Find a Solution

There are two general situations where [SOLVE] may fail to find a solution:

- [SOLVE] may be unable to find a value that sets the left side of the equation equal to the right side. The HP-22S displays `NO ROOT FND`. For example, the equation:

  `ABS(X)+Y=0`

  has no solution when $Y > 0$, since $|X|$ can never be negative.
- [SOLVE] may encounter a math error if an estimate generates an unallowed operation. For example, attempting to solve:

  `X÷Y-12=Z`

  for X with $Y=0$ displays `DIVIDE BY 0`.

See appendix B for additional information.

Obtaining More Information About [SOLVE] Results

Appendix B covers this topic in more detail.

More Information About Answers. When [SOLVE] returns an answer, pressing ■ [LAST] displays the value *left* − *right*, where *left* and *right* are the values of the left and right sides of the equation when the answer is substituted into the equation. The value in LAST should be zero or a very small number.

More Information About NO ROOT FND. When [SOLVE] returns `NO ROOT FND`, press [C] to display the final estimate for the unknown. Then, press ■ [LAST] to display the value of *left*−*right*, where *left* and *right* are the values of the left and right sides of the equation when the estimate is substituted into the equation.

More Information About Math Errors. When [SOLVE] returns a math error, press [RCL] *unknown variable* to view the final estimate. Sometimes this value can help you diagnose why [SOLVE] failed to find a solution.

7

The Equation Library

The equation library is a list of equations that are permanently stored in the HP-22S; clearing equations or all of memory does not affect the library.

Doing Calculations With Library Equations

To use a library equation:

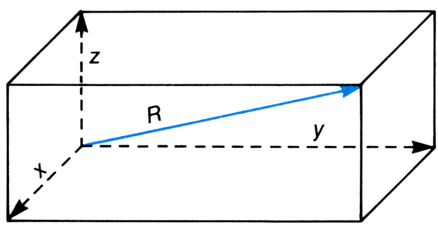
1. Select the equation by displaying it: press ■ [LIBRARY], then [▼] or ■ [▲], if necessary, to roll through the library list. You can use {→} (the [Σ+] key) to see the rest of equations longer than 12 characters.
2. Evaluate or solve the equation:
   - Use [EVAL] to *evaluate* the equation for a variable that is by itself on the left side of the equation. (The ideal gas law, thin lens, radioactive decay, and TVM equations cannot be evaluated.) If necessary see "Instructions for Using [EVAL]" on page 75.
   - Use ■ [SOLVE] to *solve* the equation for any variable. If necessary, see "Instructions for Using [SOLVE]" on page 77.

Length of a Line or Vector

An equation for the length of a line or vector $x\mathbf{i} + y\mathbf{j} + z\mathbf{k}$ is:

```
R=SQRT(X^2+Y^2+Z^2)
```

where R = the length of the line or vector.
X = the length of the x-segment.
Y = the length of the y-segment.
Z = the length of the z-segment.



Example: Length of a Vector. Calculate the length of the vector:

$$(12 - 7)\mathbf{i} + (6 - 2)\mathbf{j} + 3\mathbf{k}$$

Keys:	**Display:**	**Description:**
[EVAL]	`X?`*value*	Prompts for X.
12 [–] 7 [INPUT]	`Y?`*value*	Stores X, prompts for Y.
6 [–] 2 [INPUT]	`Z?`*value*	Stores Y, prompts for Z.
3 [INPUT]	`R=7.0711`	Stores Z, calculates the length.

Example: Length of a Line. Part 1: Calculate the hypotenuse of a right triangle with sides of 7 and 8 cm.

Keys:	Display:	Description:
[EVAL]	X?*value*	Prompts for X.
7 [INPUT]	Y?*value*	Stores *X*, prompts for *Y*.
8 [INPUT]	Z?*value*	Stores *Y*, prompts for *Z*.
0 [INPUT]	R=10.6301	Sets Z = 0, calculates the hypotenuse.

Part 2: A right triangle has a hypotenuse of 9 cm. One side equals 4 cm. Find the length of the other side.

■ [SOLVE] {X}	R?10.6301	Selects X, prompts for the hypotenuse.
9 [INPUT]	Y?8.0000	Stores *R*, prompts for *Y*.
4 [INPUT]	Z?0.0000	Stores *Y*, prompts for *Z*.
[INPUT]	X=8.0623	Retains *Z*=0, calculates X.

Roots of a Quadratic Equation

The following equation solves for the real root(s) of a quadratic equation $ax^2 + bx + c = 0$:

```
X=(-B+J×SQRT(B^2-4×A×C))÷2÷A
```

where A, B, C = the coefficients.

J = the control variable ($J = \pm 1$). To calculate both roots, evaluate the equation with $J = +1$ and $J = -1$.

Example: Find the roots of the equation $2x^2 + 12x - 20 = 0$.

Keys:	Display:	Description:
[EVAL]	B?*value*	Prompts for *B*.
12 [INPUT]	J?*value*	Stores *B*, *J*, *A*, and *C*; calculates X.
1 [INPUT]	A?*value*	
2 [INPUT]	C?*value*	
20 [+/-] [INPUT]	X=1.3589	
[EVAL]	B?12.0000	Changes sign of *J*, calculates second root.
[INPUT]	J?1.0000	
[+/-] [INPUT]	A?2.0000	
[INPUT]	C?-20.0000	
[INPUT]	X=-7.3589	

Equations of Motion

The following equations of motion describe the displacement and velocity of an object, assuming constant acceleration:

```
X=S+V×T+.5×A×T^2      (Equation #1)

F=V+A×T               (Equation #2)
```

where A = the acceleration.
F = the final velocity.
S = the initial position.
T = the elapsed time.
V = the initial velocity (at $T = 0$).
X = position at time T.

Example. Part 1: An object starting at rest accelerates with constant acceleration of 2 meters/second^2 for 5 seconds. How far does the object go?

Use equation #1:

Keys:	**Display:**	**Description:**
[EVAL]	S?*value*	Prompts for *S*.
0 [INPUT]	V?*value*	Stores *S*, prompts for *V*.
0 [INPUT]	T?*value*	Stores *V*, prompts for *T*.
5 [INPUT]	A?*value*	Stores *T*, prompts for *A*.
2 [INPUT]	X=25.0000	Stores *A*, calculates *X* (displacement).

Part 2: Calculate the object's final velocity:

■ [LIBRARY] [▼]	F=V+A×T	Displays equation #2.
[EVAL] [INPUT] [INPUT] [INPUT]	V?0.0000 A?2.0000 T?5.0000 F=10.0000	Calculates *F*, using the same values for *V*, *A*, and *T* used in part 1.

Part 3: The object stops accelerating, but continues moving at the same velocity for 3 seconds. What is the total distance it has traveled (after 8 seconds)?

■ [LIBRARY] ■ [▲]	X=S+V×T+.5×A×	Displays equation #1.
[EVAL]	S?0.0000	Prompts for *S*.
[RCL] X [INPUT]	S?25.0000 V?0.0000	Stores the final position from part 1 in *S*, prompts for *V*.
[RCL] F [INPUT]	V?10.0000 T?5.0000	Stores the final velocity from part 2 in *V*, prompts for *T*.

3 [INPUT]	A?2.0000	Stores T, prompts for A.
0 [INPUT]	X=55.0000	Sets $A = 0$, calculates X.

Example: An Object in Free-Fall. Part 1: An object is dropped from an altitude of 600 meters. What is its altitude after 5 seconds?

Use equation #1:

Keys:	**Display:**	**Description:**
[EVAL]	S?*value*	Prompts for S.
600 [INPUT]	V?*value*	Stores S, prompts for V.
0 [INPUT]	T?*value*	Stores V, prompts for T.
5 [INPUT]	A?*value*	Stores T, prompts for A.
9.8067 [+/-] [INPUT]	X=477.4163	Stores A, calculates altitude.

Part 2: How long does it take, from the time of its release, for the object to reach an altitude of 100 meters?

[■] [SOLVE] {T}	X?447.4163	Selects T, prompts for X.
100 [INPUT]	S?600.0000	Stores X, prompts for S.
[INPUT] [INPUT] [INPUT]	V?0.0000 A?-9.8067 T=10.0981	Retains previous S, V, and A, calculates T.

Kinetic Energy

The following equation calculates the kinetic energy of an object:

```
E=.5×M×V^2
```

where E = the kinetic energy of the object.
M = the mass of the object.
V = the velocity of the object.

Example. Part 1: Calculate the kinetic energy of a 5-gram object moving with a speed of 450 meters per second.

Keys:	**Display:**	**Description:**
[EVAL]	`M?`*value*	Prompts for M.
5 [÷] 1000 [INPUT]	`V?`*value*	Stores M (kg), prompts for V.
450 [INPUT]	`E=506.2500`	Stores V, calculates E (joules).

Part 2: What is the mass of an object having the same kinetic energy, but a velocity of 300 meters per second?

■ [SOLVE] {M}	`E?506.2500`	Selects M, prompts for E.
[INPUT]	`V?450.0000`	Retains E, prompts for V.
300 [INPUT]	`M=0.0113`	Stores V, calculates M (kg).
[×] 1000 [=]	`11.2500`	Calculates grams.

Force Between Two Objects

The following equation can be used to calculate the gravitational force between two masses or the electrical force between two charged objects:

```
F=K×A×B÷R^2
```

where A = the mass (in kilograms) or electrical charge (in coulombs) of object A.
B = the mass (in kilograms) or electrical charge (in coulombs) of object B.
F = the force (in newtons).
K = a constant. $K = 6.67 \times 10^{-11}$ N-m^2/kg^2 (gravitation) or $K = 8.98756 \times 10^9$ C^2/N-m^2.
R = the distance between the objects (in meters).

Example: Gravitational Force. Calculate the gravitational force between the earth and the sun. The earth's mass is 5.983×10^{24} kg; the sun's mass is 1.938×10^{30} kg. The sun is 9.3×10^7 miles from earth.

Keys:	**Display:**	**Description:**
[EVAL]	K?*value*	Prompts for K.
6.67 ■ [E] [−] 11 [INPUT]	A?*value*	Stores K, prompts for mass of object A (earth).
5.983 ■ [E] 24 [INPUT]	B?*value*	Stores A, prompts for mass of object B (sun).
1.938 ■ [E] 30 [INPUT]	R?*value*	Stores B, prompts for R.
9.3 ■ [E] 7 [×] 5280 [×] 12 [=]	R?5.8925E12	Converts miles to inches.

■ UNITS {L} {→CM}	R?1.4967E13	Converts inches to centimeters.
÷ 100 INPUT	R= 149,668,992,000.	
	F=3.4525E22	Stores *R*, calculates *F*.

Example: Coulomb's Law. Calculate the force of attraction between an electron (charge = -1.6022×10^{-19} C) and an alpha particle that are 2 angstroms apart. (An alpha particle is positively charged; the magnitude of the charge is twice that of an electron. 1 angstrom $= 10^{-10}$ m.)

Keys:	**Display:**	**Description:**
EVAL	K?*value*	Prompts for the constant.
8.98756 ■ E 9 INPUT	A?*value*	Stores *K*, prompts for electron's charge.
1.6022 +/- ■ E − 19 INPUT	B?*value*	Stores *A*, prompts for alpha particle's charge.
RCL A +/- × 2 INPUT	B=3.2044E-19 R?*value*	Calculates alpha particle's charge, stores value in *B*.
2 ■ E − 10 INPUT	F=-1.1536E-8	Stores *R* (meters), calculates *F*.

Joule's Law

The equation for Joule's Law is:

```
P=I^2×R
```

where I = the current (in amperes).
P = the power (in watts).
R = the resistance (in ohms).

Example. Heat of 50 watts develops in a resistor when the current is 1.5 amp. Calculate the resistance.

Keys:	**Display:**	**Description:**
■ [SOLVE] {R}	P?*value*	Selects *R*, prompts for *P*.
50 [INPUT]	I?*value*	Stores *P*, prompts for *I*.
1.5 [INPUT]	R=22.2222	Stores *I*, calculates *R*.

Ideal Gas Law

The Ideal Gas Law describes the relationship between pressure, volume, temperature, and amount of an ideal gas:

P×V=N×R×T

where N = the number of moles of gas.
P = the pressure (in atmospheres or N/m^2).
R = the gas law constant (0.0821 liter-atm./mole-K or 8.314 J/mole-K).
T = the temperature, in Kelvins (K = °C + 273.1).
V = the volume, in liters.

Example: Pressure of a Gas. A 2-liter bottle contains 0.005 moles of carbon dioxide gas at 24°C. Assuming that the gas behaves as an ideal gas, calculate its pressure.

Keys:	**Display:**	**Description:**
■ [SOLVE] {P}	V?*value*	Selects *P*, prompts for *V*.
2 [INPUT]	N?*value*	Stores *V*, prompts for *N*.
.005 [INPUT]	R?*value*	Stores *N*, prompts for *R*.

.0821 [INPUT]	T?*value*	Stores *R*, prompts for *T*.
24 [+] 273.1 [INPUT]	T=297.1000 P=0.0610	Calculates and stores *T* (K), calculates *P* (atm.)

Example: Density of a Gas. A 5-liter flask contains nitrogen gas. The pressure is 0.05 atmospheres when the temperature is 18°C. Calculate the gas density.

Step 1: Calculate *N*.

Keys:	**Display:**	**Description:**
■ [SOLVE] {N}	P?*value*	Selects *N*, prompts for *P*.
.05 [INPUT]	V?*value*	Stores *P*, prompts for *V*.
5 [INPUT]	R?*value*	Stores *V*, prompts for *R*.
.0821 [INPUT]	T?*value*	Stores *R*, prompts for *T*.
18 [+] 273.1 [INPUT]	T=291.1000 N=0.0105	Calculates and stores *T*, calculates *N*.

Step 2: Calculate the mass (mass = N × molecular weight; the molecular weight of nitrogen is 28).

[×] 28 [=]	0.2929	Calculates the mass.

Step 3: Calculate the density (density = mass ÷ volume):

[÷] [RCL] V [=]	0.0586	Calculates the density.

Gibb's Free Energy

The change in Gibb's free energy is calculated by the equation:

```
G=H-T×S
```

where G = the change in free energy (ΔG).
H = the change in enthalpy (ΔH).
S = the change in entropy (ΔS).
T = the temperature (in K).

Example: For a certain chemical reaction run at 25 °C, ΔH = −133.1 Kcal/mole and ΔS = 3.4 cal/K-mole. Calculate ΔG.

Keys:	Display:	Description:
[EVAL]	`H?`*value*	Prompts for H.
133.1 [+/-] [INPUT]	`T?`*value*	Stores H, prompts for T.
25 [+] 273.1 [INPUT]	`T=298.1` `S?`*value*	Calculates and stores T (K), prompts for S.
3.4 [■] [E] [-] 3 [INPUT]	`G=-134.1135`	Stores S (Kcal), calculates G (Kcal).

Pressure of a Fluid

The equation for calculating the pressure in a column of fluid is:

```
P=I+D×G×H
```

where D = the density of the fluid.
G = the acceleration of gravity.
H = the height of the column.
I = the pressure at H = 0.
P = the pressure.

Example: Roy Lawbreski's swimming pool is 3.5 meters deep under the diving board. What is the pressure at that depth. (Atmospheric pressure is 1.01×10^5 N/m^2, $G = 9.81$ m/second^2, and the density of water is 1,000 kg/m^3).

Keys:	**Display:**	**Description:**
[EVAL]	`I?`*value*	Prompts for *I*.
1.01 [■] [E] 5 [INPUT]	`D?`*value*	Stores *I*, prompts for *D*.
1000 [INPUT]	`G?`*value*	Stores *D*, prompts for *G*.
9.81 [INPUT]	`H?`*value*	Stores *G*, prompts for *H*.
3.5 [INPUT]	`P=135,335.0000`	Stores *H*, calculates pressure (N/m^2).

Radioactive Decay

The equation for radioactive decay of a substance is:

`-K×T=LN(N÷I)`

where I = the amount or activity of the substance at $T = 0$.
K = the rate constant for the decay, characteristic of the particular substance. Variables T and K must use the same time units.
N = the amount of the substance or activity at time T.
T = elapsed time.

Example: Carbon-14 Dating. Part 1: Wood on the outer surface of a giant sequoia tree exchanges carbon with its environment. The radioactivity of this wood is 15.3 counts per minute per gram of carbon. A sample of wood from the center of the tree yields 10.9 counts per minute per gram of carbon. The rate constant for the radioactive form of carbon, ^{14}C, is 1.20×10^{-4} year^{-1}. How old is the tree?

Keys:	Display:	Description:
■ [SOLVE] {T}	K?*value*	Selects T, prompts for K.
1.2 ■ [E] [−] 4 [INPUT]	N?*value*	Stores K, prompts for N.
10.9 [INPUT]	I?*value*	Stores N, prompts for I.
15.3 [INPUT]	T=2,825.7503	Stores I, calculates T (in years).

Part 2: What will be the activity of a similar sample taken 500 years in the future?

5 ■ [SOLVE] {N}	K?0.0001	Selects N. [SOLVE] will use initial guesses 5 and 10.9 (values stored in N).*
[INPUT]	T?2,825.7503	Retains K, prompts for T.
[+] 500 [INPUT]	T=3325.7503 I?15.3000	Adds 500 to previous T, prompts for I.
[INPUT]	N=10.2652	Retains I, calculates N.

The Thin Lens Equation

The thin lens equation applies to parallel light falling upon a spherical mirror or refracting surface:

$$\frac{1}{i} + \frac{1}{o} = \frac{1}{f}$$

* The guesses are necessary to prevent the LOG(NEG) error. See page 87 for additional information about entering guesses.

The library equation was obtained by multiplying the above equation by *iof*. This eliminates SOLVE errors caused by an estimate of 0 for one of the variables. (Since this form of the equation allows values of 0 for variables, you must avoid 0 values to prevent a meaningless answer.)

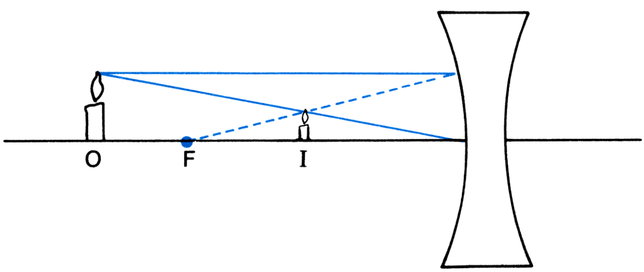
```
O×F+I×F=O×I
```

where F = the focal length. F is positive for a converging lens or concave mirror, negative for a diverging lens or convex mirror.

I = the distance between the image and the vertex. I is negative for a virtual image.

O = the distance between the object and the vertex. O is negative for a virtual object.

Example: A thin diverging lens has a focal length of 30 cm. Describe the image formed by the lens when an object is located 45 cm from the vertex.



Keys:	**Display:**	**Description:**
■ SOLVE {I}	O?*value*	Selects I, prompts for O.
45 INPUT	F?*value*	Stores O, prompts for F.
30 +/- INPUT	I=-18.0000	The *virtual* image is 18 cm from the lens.

Diffraction

The angular separation of the interference fringes produced by a diffration grating is defined by the equation:

A=ASIN(M×L÷D)

where A = the angle.
D = the grating spacing.
L = the wavelength of light.
M = the order number; M = 0, 1, 2, etc.

Example: Light with a wavelength of 5,890 angstroms illuminates a grating with 4,000 rules/cm. Calculate the angle of the first order maximum. (1 angstrom = 10^{-8} cm.)

Keys:	**Display:**	**Description:**
■ [MODES] {DG}		Sets Degrees mode.
[EVAL]	M?*value*	Prompts for M.
1 [INPUT]	L?*value*	Stores M, prompts for L.
5890 ■ [E] [-] 8 [INPUT]	D?*value*	Stores L (cm), prompts for D.
4000 [1/x] [INPUT]	A=13.6270	Stores D (cm/rule), calculates A (degrees).

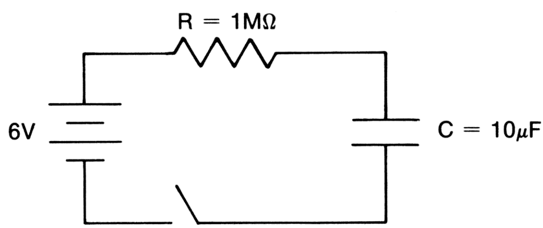
Calculations Based on First-Order Linear Differential Equations

The following equation can be used for a wide variety of calculations involving exponential growth and decay:

`Y=F+(I-F)×EXP(K×T)`

where
K = the growth or decay constant.
F = the final value. F occurs at $T = +\infty$ for negative values of K, and at $T = -\infty$ for positive values of K.
I = the value at $T = 0$.
T = elapsed time.
Y = the value at time T.

Example: An RC Circuit. Part 1. For the circuit shown below, calculate the voltage across the capacitor 5 seconds after the switch is closed. At $T = 0$, the voltage across the capacitor is 0. ($K = -1 \div (R \times C)$).



Keys:	Display:	Description:
[EVAL]	`F?`*value*	Prompts for F.
6 [INPUT]	`I?`*value*	Stores F (voltage at $T = \infty$), prompts for I.
0 [INPUT]	`K?`*value*	Stores I (the voltage before the switch is closed), prompts for K.
■ [E] 6 [×] 10 ■ [E] −6 [=] [1/x] [+/-] [INPUT]	`K=-0.1000` `T?`*value*	Calculates and stores K, prompts for T.

5 [INPUT]	Y=2.3608	Stores T, calculates Y.

Part 2: What applied voltage is required in order to attain 4 V across the capacitor after 5 seconds? (Solve for F—the voltage applied to the circuit *and* the final voltage across the capacitor.)

■ [SOLVE] {F}	Y?2.3608	Selects F, prompts for Y.
4 [INPUT]	I?0.0000	Retains previous I, K, and T, calculates F.
[INPUT]	K?-0.1000	
[INPUT]	T?5.0000	
[INPUT]	F=10.1660	

Root Mean Square

The following equation uses the statistics registers to calculate the *root mean square,* or quadratic mean, of a set of numbers:

R=SQRT(Σx²÷n)

where R = the root mean square.

Example: Calculate the root mean square of the data 3, 4, 5, 6, 6, 7, 9.

Keys:	**Display:**	**Description:**
■ [CLEAR] {Σ}		Clears the statistics registers.
3 [Σ+] 4 [Σ+] 5 [Σ+] 6 [Σ+] 6 [Σ+] 7 [Σ+] 9 [Σ+]	n=7.0000	Enters the statistics data.

If necessary, make the root mean square equation the present equation. Then:

[EVAL]	R=6.0000	Calculates the root mean square.

Time Value of Money

The phrase *time value of money* (TVM) describes calculations based on cash flows (money received or money paid) earning *compound interest* over a period of time. *Compound interest* calculations take into account that interest, added to the principal at specified compounding periods, also earns interest. Many financial problems are TVM problems—for example, savings accounts, mortgages, pension funds, leases, and annuities.

The TVM equation is:

```
(P×100÷I-F)×(1+I÷100)^-N-P×100÷I=B
```

where B = the *beginning value* (also called the *present value*) of the series of future cash flows. To a lender or borrower, B is the amount of the loan; to an investor, B is the initial investment. B always occurs at the beginning of the first period.

F = the *future value*—the amount of the final cash flow, or the compounded value of the series of previous cash flows. F always occurs at the end of the last period.

I = the periodic interest rate, expressed as a percent. For example, if an account earns 10% annual interest, compounded monthly, its periodic rate is $^{10}/_{12}$, or 0.8333%

N = the total number of payments or compounding periods. N can be expressed in any unit of time—for example, years, months, or days.*

P = amount of each periodic payment. The payments are the same amount, and no payments are skipped. Payments occur at the end of each period.

* When SOLVE calculates a non-integer N, the answer must be interpreted carefully, since the equation does not calculate partial period payments. Calculations using a stored non-integer N produce mathematically correct results, but the results have no simple useful interpretation.

In order to use the TVM equation, the cash flows (money received for money paid) must meet the following requirements:

- The dollar amount is the same for each payment.
- The payments occur at regular intervals.
- Payment periods coincide with the compounding periods.
- Payments occur at the end of each period.

Sign Convention. The sign convention for TVM problems is:

- Money received is a positive value.
- Money paid out is a negative value.

Cash-Flow Diagrams. It is helpful to illustrate TVM calculations with *cash flow diagrams*. Cash flow diagrams are time lines divided into payment periods or compounding periods. Arrows show the cash flows, pointing up for positive cash flows and down for negative cash flows.

The cash flow diagram for a transaction depends on the point of view of the problem. For example, a loan is an initial positive cash flow for the borrower and an initial negative cash flow for the lender.

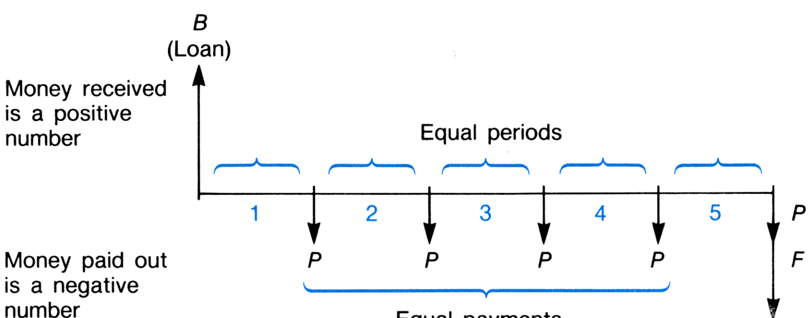


Figure 7-1. Loan From a Borrower's Point of View

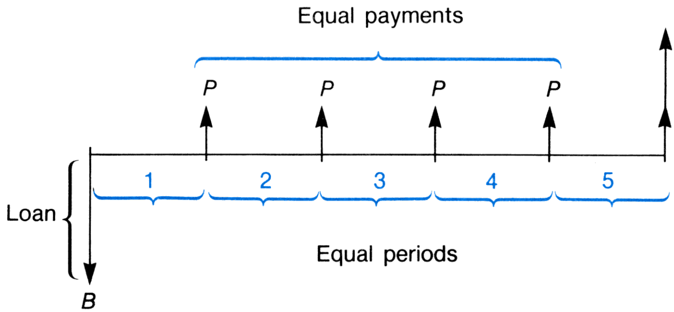
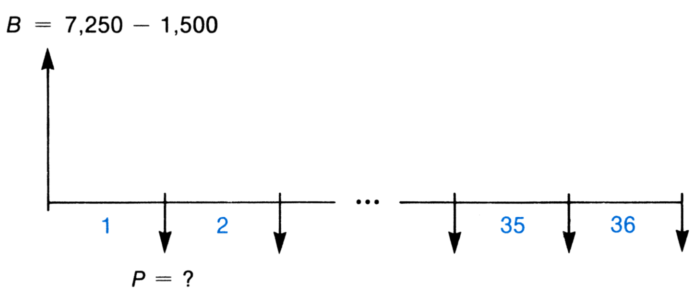


Figure 7-2. Loan From a Lender's Point of View

Example: A Car Loan. Part 1: You are financing the purchase of a car with a 3-year loan at 10.5% annual interest, compounded monthly. The purchase price of the car is $7,250. Your down payment is $1,500. What are your monthly payments? (Assume payments start one month after purchase—in other words, at the *end* of the first period.)



Keys:	**Display:**	**Description:**
■ DISP {FX} 2		Sets display to two decimal places.
■ SOLVE {P}	`I?`*value*	Selects *P*, prompts for *I*.
10.5 ÷ 12 INPUT	`I=0.88` `F?`*value*	Calculates and stores *I*, prompts for *F*.

0 [INPUT]	N?*value*	Stores *F*, prompts for *N*.
36 [INPUT]	B?*value*	Stores *N*, prompts for *B*.
7250 [−] 1500 [INPUT]	B=5,750.00 P=-186.89	Calculates and stores *B*, calculates *P*.

Part 2: What interest rate would you have to get to reduce your monthly payment by $10?

■ [SOLVE] {I}	P?-186.89	Selects *I*, prompts for *P*.
[+] 10 [INPUT]	P=-176.89 F?0.00	Calculates and stores reduced P, prompts for *F*.
[INPUT] [INPUT] [INPUT]	N?36.00 B?5,750.00 I=0.56	Retains previous *F*, *N* and *B*, calculates *I*.
[×] 12 [=]	6.75	Calculates annual interest rate.

See chapter 8 for additional TVM examples.

8

Additional Examples

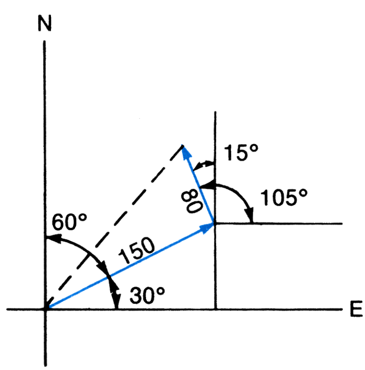
Vector Calculations

The following examples use polar/rectangular coordinate conversions to do vector operations.

Adding Two Vectors in Polar Coordinates

The sum of two vectors $x_1\mathbf{i}+y_1\mathbf{j}$ and $x_2\mathbf{i}+y_2\mathbf{j}$ is $(x_1+x_2)\mathbf{i} + (y_1+y_2)\mathbf{j}$.

Example: Part 1: A ship travels 150 miles on a course 60° east of north, and then travels an additional 80 miles on a course 15° west of north. How far is the ship from its starting point?



Keys:	**Display:**	**Description:**
■ MODES {DG}		Sets Degrees mode.
150 ■ RADIUS 30 ■ ANGLE	r=150.0000 θ=30.0000	Enters r and θ for first leg.
■ xCOORD STO X	x=129.9038	Calculates x_1 and stores value in variable X.
■ yCOORD STO Y	y=75.0000	Calculates y_1 and stores value in variable Y.
80 ■ RADIUS 105 ■ ANGLE	r=80.0000 θ=105.0000	Enters second leg.
■ xCOORD STO + X	x=-20.7055	Calculates x_2 and adds it to contents of X.
■ yCOORD STO + Y	y=77.2741	Calculates y_2 and adds it to contents of Y.
RCL X ■ xCOORD	x=109.1983	Stores x_1+x_2 in x.
RCL Y ■ yCOORD	y=152.2741	Stores y_1+y_2 in y.
■ RADIUS	r=187.3810	Calculates distance from starting point.

Part 2: In what direction has the ship traveled from its starting point?

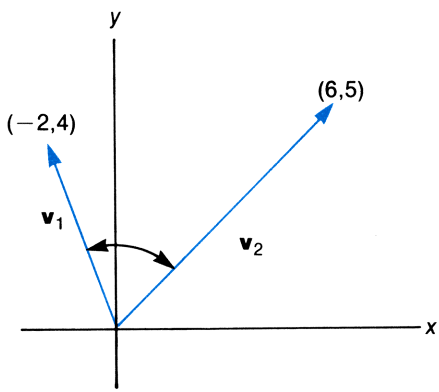
■ ANGLE	θ=54.3551	Calculates angle from starting point, counterclockwise from east.

Angle Between Two Vectors

The angle between vectors $\mathbf{v}_1 = x_1\mathbf{i} + y_1\mathbf{j}$ and $\mathbf{v}_2 = x_2\mathbf{i} + y_2\mathbf{j}$ can be calculated by converting both vectors to polar coordinates and calculating the difference between the two angles.

Example: Find the angle between:

$$\mathbf{v}_1 = -2\mathbf{i} + 4\mathbf{j}$$
$$\mathbf{v}_2 = 6\mathbf{i} + 5\mathbf{j}$$



Keys:	**Display:**	**Description:**
■ MODES {DG}		Sets Degrees mode.
6 ■ xCOORD 5 ■ yCOORD	x=6.0000 y=5.0000	Stores x and y for $\mathbf{v}_2$.
■ ANGLE STO A	θ=39.8056	Calculates θ for $\mathbf{v}_2$ and stores value in variable A.
2 +/− ■ xCOORD 4 ■ yCOORD	x=-2.0000 y=4.0000	Stores x and y for $\mathbf{v}_1$.
■ ANGLE	θ=116.5651	Calculates θ for $\mathbf{v}_1$.
− RCL A =	76.7595	Calculates angle between $\mathbf{v}_1$ and $\mathbf{v}_2$.

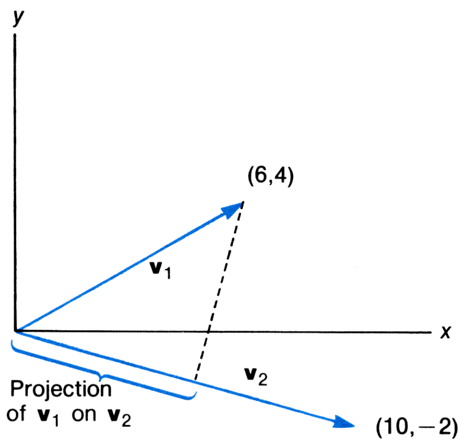
Projection of One Vector on Another

The projection of vector $\mathbf{v}_1 = x_1\mathbf{i} + y_1\mathbf{j}$ on vector $\mathbf{v}_2 = x_2\mathbf{i} + y_2\mathbf{j}$ has the direction of $\mathbf{v}_2$ and:

$$\text{Length} = \frac{x_1 x_2 + y_1 y_2}{|\mathbf{v}_2|}$$

where $|\mathbf{v}_2|$ is the length of $\mathbf{v}_2$.

Example: Find the projection of $6\mathbf{i}+4\mathbf{j}$ on $10\mathbf{i}-2\mathbf{j}$.



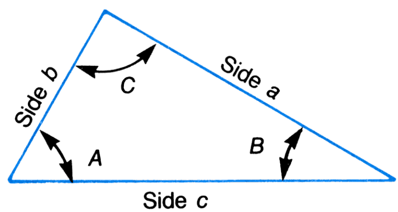
Keys:	**Display:**	**Description:**
■ MODES {DG}		Sets Degrees mode.
10 ■ xCOORD 2 +/- ■ yCOORD	x=10.0000 y=-2.0000	Stores x and y for $\mathbf{v}_2$.
■ ANGLE	θ=-11.3099	Calculates θ for $\mathbf{v}_2$.
■ RADIUS	r=10.1980	Calculates $\|\mathbf{v}_2\|$.
1/x	0.0981	Calculates $1/\|\mathbf{v}_2\|$.
× (6 × 10 + 4 × 2 +/-)	×52.0000	$x_1x_2 + y_1y_2 = 52$.

■ RADIUS	r=5.0990	Calculates and stores projection length.
■ xCOORD	x=5.0000	Calculates x for projection.
■ yCOORD	y=-1.0000	Calculates y for projection.

The projection vector is $5\mathbf{i}-1\mathbf{j}$.

Laws of Sines and Cosines

The law of sines and law of cosines apply to all triangles:



Law of sines:

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

Use when you know:

- One side, two angles.
- Two sides, angle opposite a known side.

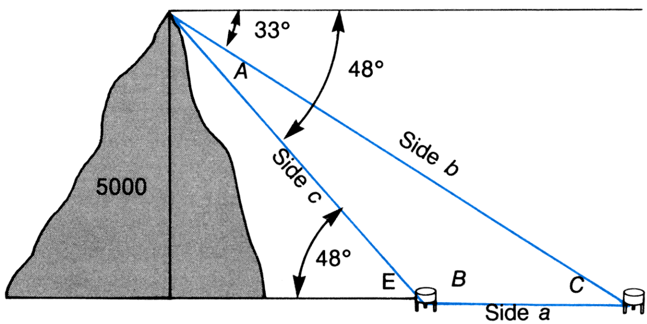
Law of cosines:

$$a^2 = b^2 + c^2 - 2bc \cos A$$

Use when you know:

- Two sides, angle between them.
- Three sides.

Example: Law of Sines. You look down from the top of a 5000-foot mountain with your telescope and see two large water towers, one behind the other. When you point the telescope at one tower, the angle from horizontal is 33°. For the other tower, the angle from horizontal is 48°. How far apart are the towers?



The unknown is side a of triangle ABC. Angles A, B, and C are easily found:

$A = 48 - 33 = 15°$
$B = 180 - 48 = 132°$
$C = 180 - (15 + 132) = 33°$

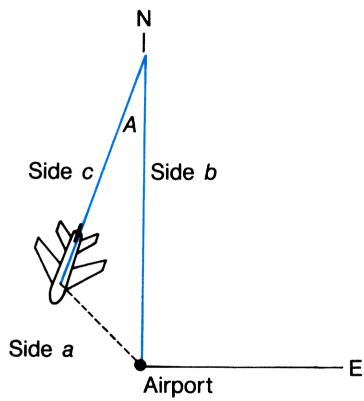
Side a can be calculated using the law of sines if we know any other side. We do, since $c \sin E = 5000$, and $E = 180 - 132 = 48°$. Therefore, $c = 5000 \div \sin 48°$.

Keys:	**Display:**	**Description:**
■ [MODES] {DG}		Sets Degrees mode.
5000 [÷] 48 [SIN] [=]	6,728.1636	Calculates side c.

Now, use the law of sines to calculate side a; $a = c \sin A \div \sin C$:

[×] 15 [SIN] [÷]	1,741.3769÷	
33 [SIN] [=]	3,197.3046	Calculates side a.

Example: Law of Cosines. A plane travels north for 175 miles before turning around. On the return trip, a strong wind from the east pushes the plane 18° off course. After traveling 150 miles, how far is the plane from the airport?



Two sides and the angle between them are known:

$b = 175$
$c = 150$
$A = 18°$

By the law of cosines, $a = \sqrt{(b^2 + c^2 - 2bc \cos A)}$.

Keys:	**Display:**	**Description:**
■ [MODES] {DG}		Sets Degrees mode.
175 ■ [x^2] [+]	30,625.0000+	
150 ■ [x^2] [−]	53,125.0000−	
2 [×] 175 [×] 150 [×]	52,500.0000×	
18 [COS]	×0.9511	Calculates cosine of 18°.
[=] [$\sqrt{x}$]	56.5202	Distance from airport.

Covariance

The equation for calculating the covariance of *x,y*-data is:

$$Covariance = \frac{\Sigma\,[(x - \bar{x})(y - \bar{y})]}{n}$$

To calculate the covariance:

1. Store the following equation into the list of equations:

   `P=(X-x̄)×(Y-ȳ)÷n`

   To store the equation, press [EQUATIONS], then [▼] (if necessary) until the HP-22S displays `TYPE NEW EQN`. Type the equation ([STAT] {x̄,ȳ} {x̄} types x̄; [STAT] {x̄,ȳ} {ȳ} types ȳ; [STAT] {Σ} {n} types n) and press [INPUT].
2. Clear the statistical registers by pressing [CLEAR] {Σ}.
3. Enter the *x,y*-data into the statistics registers.
4. For each set of *x,y*-data, evaluate the equation. Accumulate the results in variable *C* using [STO] [+].
5. Recall the contents of variable *C*. This value is the covariance.

Example: Calculate the covariance of the following data:

X	6	7	8	9	9
Y	3	4	4	5	6

Keys:	**Display:**	**Description:**
6 [INPUT] 3 [Σ+]		Enters the data.
7 [INPUT] 4 [Σ+]		
8 [INPUT] 4 [Σ+]		
9 [INPUT] 5 [Σ+]		
9 [INPUT] 6 [Σ+]	`n=5.0000`	

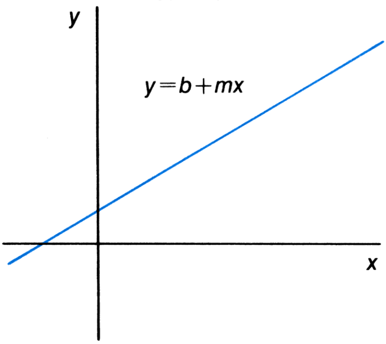
Make sure `P=(X-x̄)×(Y-ȳ)÷n` is the current equation. Then:

[EVAL]		Evaluates the equation.
6 [INPUT] 3 [INPUT]	`P=0.5040`	
[STO] C	`C=0.5040`	Stores value into *C*.
[EVAL] 7 [INPUT] 4 [INPUT]	`P=0.0640`	Evaluates the equation.
[STO] [+] C	`P=0.0640`	Adds 0.064 to contents of *C*.
[EVAL] 8 [INPUT] [INPUT] [STO] [+] C	`P=-0.0160`	Calculates *P*, accumulates *C* for 3rd point.
[EVAL] 9 [INPUT] 5 [INPUT] [STO] [+] C	`P=0.1440`	Calculates *P*, accumulates *C* for 4th point.
[EVAL] [INPUT] 6 [INPUT] [STO] [+] C	`P=0.3840`	Calculates and accumulates *C* for 5th point.
[RCL] C	`C=1.0800`	Recalls *C*, the covariance.

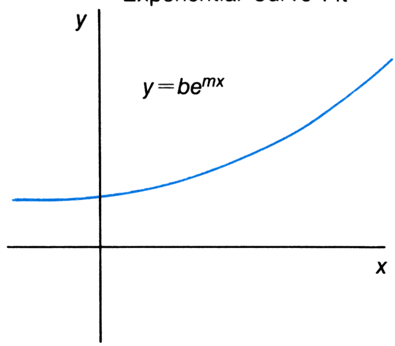
Non-Linear Curve-Fitting

The *linear regression* (L.R.) menu can be used to do curve fitting for the logarithmic, exponential, and power models.

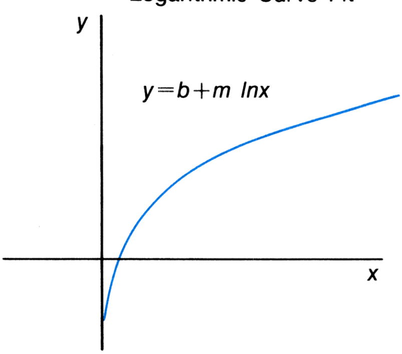
Linear Curve Fit



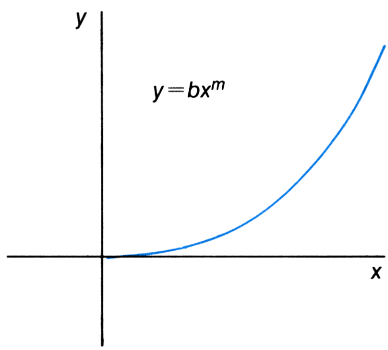
Exponential Curve Fit



Logarithmic Curve Fit



Power Curve Fit



In order to use linear regression for those models, the data must undergo the appropriate transformations.

Curve Fitting Models and Transformations

Model	Equation	Transformed Equation	Transformed Data
Logarithmic	$y = b + m \ln x$	$y = b + m \ln x$	$\ln(x)$, y $(x>0)$
Exponential	$y = be^{mx}$	$\ln(y) = \ln(b) + mx$	x, $\ln(y)$ $(y>0)$
Power	$y = bx^m$	$\ln(y) = \ln(b) + m \ln(x)$	$\ln(x)$, $\ln(y)$ $(x>0,\ y>0)$

Example: The Power Model. Part 1: The following equation defines the relationship between the pressure and volume of a non-ideal gas:

$$C = PV^g$$

where C and g are constants. Calculate the constants for the following data:

Volume (liters)	50	100	150	200	250
Pressure (torr)	110	48	30	21	16

Taking the natural log of both sides of the equation and rearranging it yields:

$$\ln P = \ln C - g \ln V$$

The equation now has the form $\ln y = \ln b + m \ln x$, which is the transformation for the power model. A plot of $\ln y$ versus $\ln x$ should result in a straight line with a slope of $-g$ and a y-intercept of $\ln C$.

Keys:	**Display:**	**Description:**
■ [CLEAR] {Σ}		Clears the statistics registers.
50 [LN] [INPUT] 110 [LN] [Σ+]	`3.9120:` `n=1.0000`	Enters 1st data pair.

100 [LN] [INPUT] 48 [LN] [Σ+]	4.6052: n=2.0000	Enters 2nd data pair.
150 [LN] [INPUT] 30 [LN] [Σ+]	5.0106: n=3.0000	Enters 3rd data pair.
200 [LN] [INPUT] 21 [LN] [Σ+]	5.2983: n=4.0000	Enters 4th data pair.
250 [LN] [INPUT] 16 [LN] [Σ+]	5.5215: n=5.0000	Enters final data pair.
[STAT] {L.R.} {m}	m=-1.1953	$g = 1.1953$.
[STAT] {L.R.} {b}	b=9.3787	Displays y-intercept (ln C).
[e^x]	11,834.1511	Calculates C.

Part 2: How well does the data fit the curve?

[STAT] {L.R.} {r} [■] [SHOW]	r=-1.0000 -999958547711	$\lvert r \rvert$ very close to 1 indicates an excellent fit.

Part 3: Estimate the pressure at $V = 125$ liters.

125 [LN]	4.8283	Calculates tranformed V.
[STAT] {L.R.} {ŷ}	ŷ=3.6073	Calculates estimate for ln P.
[e^x]	36.8647	Calculates estimate for P.

Probability Calculations

The following calculations use the PROB menu and the relationship:

$$\text{Probability of an event} = \frac{\text{\# of combinations that produce the event}}{\text{total \# of combinations}}$$

Example. Part 1: A company employing 14 women and 10 men is forming a six-person committee to deal with health and safety issues. How many different combinations of people are possible?

Keys:	**Display:**	**Description:**
24 [INPUT] 6 [■] [PROB] {Cn,r}	134,596.0000	Calculates number of combinations.

Part 2: If employees are chosen at random, what is the probability that the committee will contain six women?

[STO] C	C=134,596.0000	Stores previous result.
14 [INPUT] 6 [■] [PROB] {Cn,r}	3,003.0000	Calculates number of combinations of six women.
[÷] [RCL] C [=]	0.0223	Probability of committee being all women.

Part 3: If employees are chosen at random, what is the probability that the committee will contain equal numbers of men and women?

10 [INPUT] 3 [■] [PROB] {Cn,r}	120.0000	Calculates combinations of 10 men, 3 at a time.
[STO] M	M=120.0000	Stores value in *M*.
14 [INPUT] 3 [■] [PROB] {Cn,r}	364.0000	Calculates combinations of 14 women taken 3 at a time.
[×] [RCL] M [=]	43,680.0000	Number of 6-person committees with 3 men and 3 women.
[÷] [RCL] C [=]	0.3245	Probability of the committee containing 3 men and 3 women.

Part 4: The Safety Officer, Don Jimmally, *must* be on the committee. How many combinations are possible? (Since one employee *must* be on the committee, there are five openings for the 23 remaining employees).

23 [INPUT] 5 ■ [PROB] {Cn,r}	33,649.0000	Number of combinations of 23 taken 5 at a time.

Part 5: Once the committee members are chosen, how many ways can they arrange themselves in a room containing six chairs? (There are 6! ways of seating themselves.)

6 ■ [PROB] {n!}	720.0000	Calculates 6!.

Part 6: If there are 7 chairs in the room, how many seating arrangements are possible?

7 [INPUT] 6 ■ [PROB] {Pn,r}	5,040.0000	Permutations of 7 taken 6 at a time.

Motion of a Projectile

The equations:

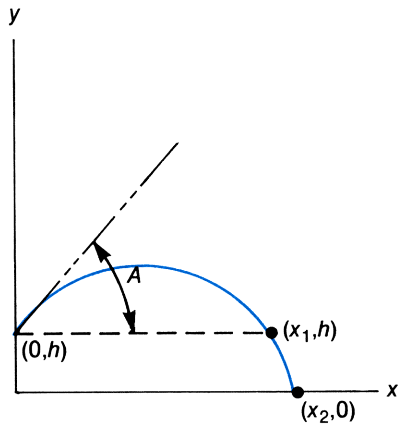
```
X=V×T×COS(A)                 (Equation #1)
Y=H+V×T×SIN(A)-.5×G×SQ(T)    (Equation #2)
```

define the position of a projectile

where A = the initial angle from the horizontal axis.
G = the acceleration of gravity (32.2 feet/second^2).
H = the height above the ground at $T = 0$.
T = the flight time.
V = the initial velocity.
X = the horizontal displacement at time T.
Y = the height above the ground at time T.

Entering the Equations. Press ■ EQUATIONS, then ▼ (if necessary) until the HP-22S displays `TYPE NEW EQN`. Type equation #1 and press INPUT. Press ▼, type equation #2 (■ x^2 types `SQ(`) and press INPUT.

Example: Part 1: Shot-putter Hi Hurler can "put" a shot-put with an initial velocity of 34 feet/second. If the initial angle of the trajectory is 43°, and the shot-put is released at a height of 5 feet, how far can Hi throw?



Since X is a function of T, you must first solve for T using the second equation. Press ■ EQUATIONS and display equation #2. Then:

Keys:	**Display:**	**Description:**
C ■ MODES {DG}		Sets Degrees mode.
1 STO T 5 ■ SOLVE	`A G H T V Y`	Enters 1 and 5 as guesses for T.
{T}	`Y?`*value*	Selects T, prompts for Y.
0 INPUT	`H?`*value*	Stores Y, prompts for H.
5 INPUT	`V?`*value*	Stores H, prompts for V.

34 [INPUT]	A?*value*	Stores V, prompts for A.
43 [INPUT]	G?*value*	Stores A, prompts for G.
32.2 [INPUT]	T=1.6307	Stores G, calculates T.

Now, you can use equation #1 to calculate the horizontal displacement:

■ [EQUATIONS] ■ [▲]	X=V×T×COS(A)	Switches to equation #1.
[EVAL] [INPUT] [INPUT] [INPUT]	V?34.0000 T?1.6307 A?43.0000 X=40.5488	Retains previous values for V, T, and A; solves for X.

Part 2: What is the highest altitude the shot-put reaches? (The maximum altitude occurs in exactly half the time it takes the shot-put to fly from $(0,h)$ to (x_1,h)).

■ [EQUATIONS] [▼]	Y=H+V×T×SIN(	Displays equation #2.
[C] 1 [STO] T 5 ■ [SOLVE] {T}	Y?0.0000	Enters guesses for T, prompts for Y.
5 [INPUT]	H?5.0000	Stores 5 for Y, prompts for H.
[INPUT] [INPUT] [INPUT] [INPUT]	V?34.0000 A?43.0000 G?32.20000 T=1.4402	Retains previous values for H, V, A, G, T; solves for time required to reach (x_1,h).
[÷] 2 [=] [STO] T	T=0.7201	Calculates time required to reach maximum altitude, stores value in T.

EVAL	H?5.0000	Retains all variable values, calculates maximum altitude.
INPUT	V?34.0000	
INPUT	T?0.7201	
INPUT	A?43.0000	
INPUT	G?32.2000	
INPUT	Y=13.3491	

The Catenary Equation

The curve formed by suspending a flexible cable from two points is called a *catenary*, and is defined by the two equations:

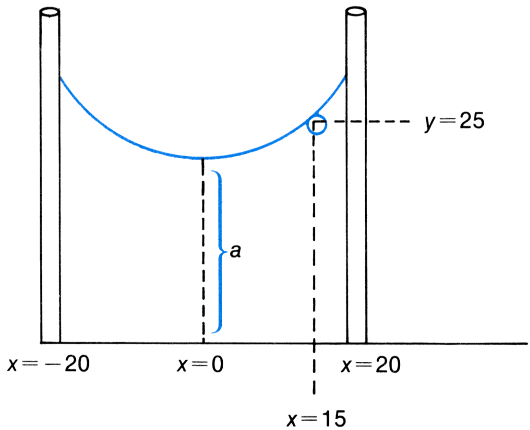
Y=A×COSH(X÷A) (Equation #1)

L=2×A×SINH(X÷A) (Equation #2)

where A = the height at the midpoint (the lowest height).
L = the cable length.
X = the horizontal distance from the midpoint.
Y = the height at any X-value except $X = 0$.

Entering the Equations. Press ■ EQUATIONS, then ▼ (if necessary) until the HP-22S displays TYPE NEW EQN. Type equation #1 and press INPUT. Press ▼, type equation #2, and press INPUT.

Example: Part 1: You want to suspend a cable between two poles that are 40 feet apart. The cable must pass under a tree limb 25 feet high located 5 feet from one of the poles. How far off the ground will the cable be at its lowest point?



You can use the one known point (15,25) to calculate *A*. Press ■ EQUATIONS and display equation #1. Then, since there can be more than one solution to the equation, enter guesses for *A*:

Keys:	**Display:**	**Description:**
C 10 STO A 20 ■ SOLVE	`A X Y`	Enters guesses 10 and 20 for *A*.
{A}	`Y?`*value*	Selects *A*; prompts for *Y*.
25 INPUT	`X?`*value*	Stores *Y*, prompts for *X*.
15 INPUT	`A=18.6268`	Stores *X*, solves for *A*.

Part 2: At what height should the cable be attached to the poles? (Find Y at $X=20$):

[EVAL]	`A?18.6268`	Prompts for A.
[INPUT]	`X?15.000`	Retains previous A, prompts for X.
20 [INPUT]	`Y=30.4360`	Calculates height at end of cable.

Part 3: What length of cable is needed?

■ [EQUATIONS] [▼]	`L=2×A×SINH(X`	Displays the second equation.
[EVAL]	`A?18.6268`	Prompts for A.
[INPUT] [INPUT]	`X?20.0000` `L=48.1413`	Retains previous values for A and X, calculates L.

Distance Between Two Locations

If the longitude and latitude of two locations are known, the distance between them can be calculated by the equation:

```
D=69.094×ACOS(SIN(HR(A))×SIN(HR(T))+COS(HR(A))×
COS(HR(T))×COS(HR(O)-HR(G)))
```

where D = the distance between the two places in statute miles.
A = the **l**atitude of the first place.
O = the l**o**ngitude of the first place.
T = the la**t**itude of the second place.
G = the lon**g**itude of the second place.

The longitudes and latitudes are entered in degrees-minutes-seconds format (D.MMSSss); South Latitude and East Longitude are negative numbers. The calculator must be in Degrees mode.

Entering the Equation. Press ■ [EQUATIONS], then [▼] (if necessary) until the HP-22S displays `TYPE NEW EQN`. Type the equation (■ [H↔HMS] {→HR} types `HR(`) and press [INPUT].

Example: Calculating the Distance Between Two Places. Find the statute miles between Philadelphia, Pennsylvania (40°35′N, 75°10′W) and Corvallis, Oregon (44°35′N, 123°16′W).

Keys:	Display:	Description:
[C] ■ [MODES] {DG}		Sets Degrees mode.
[EVAL]	`A?`*value*	Prompts for $latitude_1$.
40.35 [INPUT]	`T?`*value*	Stores *A*, prompts for $latitude_2$.
44.35 [INPUT]	`O?`*value*	Stores *T*; prompts for $longitude_1$.
75.1 [INPUT]	`G?`*value*	Stores *O*; prompts for $longitude_2$.
123.16 [INPUT]	`D=2,426.9794`	Calculates statute miles.

Interest Rate Conversions

Interest rates are generally stated as *nominal interest rates*. A nominal interest rate is an annual rate that is compounded *periodically*—for example, 18% per year, compounded monthly (12 times per year). When investments have different compounding periods, *effective interest rates* are used to compare them. The effective rate is the annual rate that would produce the same interest earnings as the nominal rate compounded *P* times per year. For example, earning 18% annual rate compounded monthly (nominal rate) is equivalent to earning 19.56% annual interest.

There are two compounding methods and two corresponding equations:

- Periodic compounding; for example, quarterly, monthly, or daily compounding.

  `E=((1+N÷(100×P))^P-1)×100`

- Continuous compounding.

  `E=(EXP(N÷100)-1)×100`

where	E	=	the effective percentage interest rate.
	N	=	the nominal percentage interest rate.
	P	=	the number of compounding periods per year.

Entering the Equations. Press ■ [EQUATIONS], then [▼] (if necessary) until the HP-22S displays `TYPE NEW EQN`. Type the periodic compounding equation and press [INPUT]. Press [▼], type the continuous compounding equation ([y^x] types `^`, [e^x] types `EXP(`), and press [INPUT].

Example: Interest Rate Conversions. You are considering opening a savings account in one of three banks. Which bank has the most favorable interest rate to you?

Bank #1	6.7% annual interest, compounded quarterly
Bank #2	6.66% annual interest, compounded monthly
Bank #3	6.65% annual interest, compounded continuously

Press ■ [EQUATIONS] and display the periodic compounding equation. Then:

Keys:	**Display:**	**Description:**
[EVAL]	`N?`*value*	Prompts for N.
6.7 [INPUT]	`P?`*value*	Stores N, prompts for P.
4 [INPUT]	`E=6.8702`	Calculates E for bank #1.
[EVAL]	`N?6.7000`	Prompts for N.

6.66 [INPUT]	P?4.0000	Stores N, prompts for P.
12 [INPUT]	E=6.8671	Calculates E for bank #2.
■ [EQUATIONS] [▼]	E=(EXP(N÷100	Displays the continuous compounding equation.
[EVAL]	N?6.6600	Prompts for N.
6.65 [INPUT]	E=6.8761	Retains previous value of N, calculates E for bank #3.

Bank #3 is offering the most favorable interest rate.

Time Value of Money Calculations

The following examples use the time value of money equation in the library. To display the equation, press ■ [LIBRARY]. If necessary, press [▼] until the HP-22S displays the beginning of the equation (`(P×100÷I-F)×`).

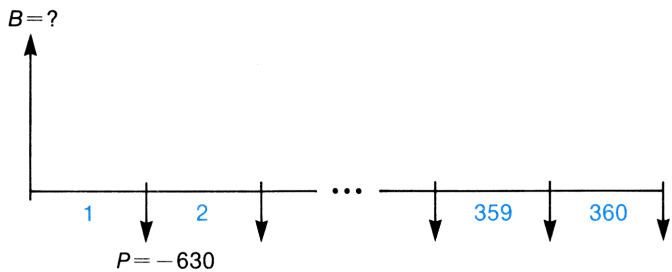
The time value of money variables are described on page 109. Following is a brief description of each variable:

B = the *beginning value* (also called the *present value*) of the series of future cash flows.

F = the *future value*—the amount of the final cash flow, or the compounded value of the series of previous cash flows.

I = the periodic interest rate, expressed as a percent.
N = the total number of payments or compounding periods.
P = amount of each periodic payment. Payments occur at the end of each period.

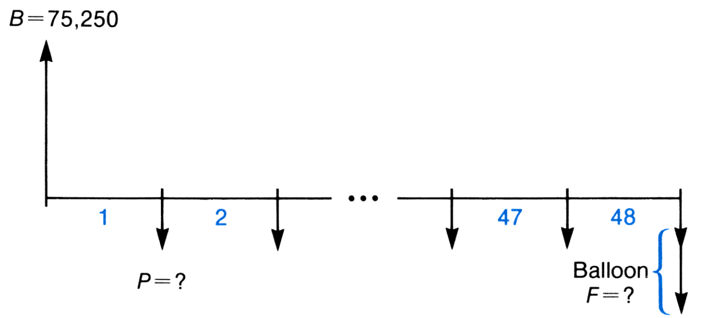
Example: A Mortgage. You've decided that the maximum monthly mortgage payment you can afford is $630. You can make a $12,000 down payment, and the annual interest rate is 11.5%. If you take out a 30-year mortgage, what is the maximum purchase price you can afford?



Keys:	**Display:**	**Description:**
■ [DISP] {FX} 2		Sets display to two decimal places.
■ [SOLVE] {B}	P?*value*	Selects B, prompts for P.
630 [+/-] [INPUT]	I?*value*	Stores P, prompts for I.
11.5 [÷] 12 [INPUT]	F?*value*	Stores I, prompts for F.
0 [INPUT]	N?*value*	Stores F, prompts for N.

30 [×] 12 [INPUT]	B=63,617.64	Stores *N*, calculates loan amount.
[+] 12000 [=]	75,617.64	Calculates total price (loan plus down payment).

Example: A Mortgage With a Balloon Payment. You've taken out a 25-year, $75,250 mortgage at 13.8% annual interest. You anticipate that you will own the house for four years and then sell it, repaying the loan in a "balloon payment." What will be the size of your balloon payment at the end of four years?



The problem is done in two steps:

1. Calculate the monthly payment. This calculation is done using the total length of the loan (25 years), assuming no balloon payment.
2. Calculate the balloon payment after 4 years. Use the monthly payment rounded to dollars and cents for *P*.*

* The payment calculated in step #1 is stored as a 12-digit number. The calculation of the balloon payment must use the actual dollars and cents monthly payment amount.

Keys:	Display:	Description:
■ [DISP] {FX} 2		Sets display to two decimal places.

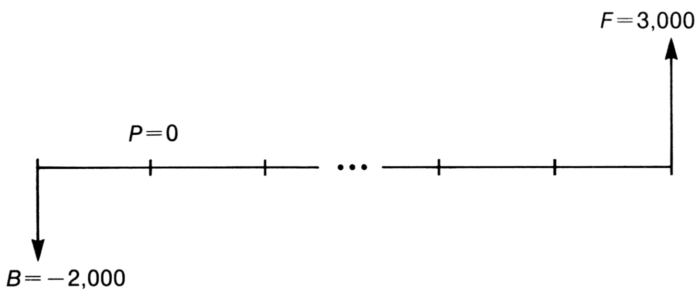
Step 1: Calculate the payment for the mortgage.

■ [SOLVE] {P}	I?*value*	Selects *P*, prompts for *I*.
13.8 [÷] 12 [INPUT]	F?*value*	Stores *I*, prompts for *F*.
0 [INPUT]	N?*value*	Stores *F*, prompts for *N*.
25 [×] 12 [INPUT]	B?*value*	Stores *N*, prompts for *B*.
75250 [INPUT]	P=-894.33	Stores *B*, calculates monthly payment.

Step 2. Calculate the balloon payment after 4 years:

■ [SOLVE] {F}	P?-894.33	Selects *F*, prompts for *P*.
■ [PARTS] {RN} [INPUT]	I?1.15	Stores rounded value of *P*, prompts for *I*.
[INPUT]	N?300.00	Retains previous *I*, prompts for *N*
4 [×] 12 [INPUT]	B?75,250.00	Stores *N* for 4 years, prompts for *B*.
[INPUT]	F=-73,408.81	Retains previous *B*, calculates balloon payment. This amount plus the last monthly payment repays the loan.

Example: A Savings Account. You deposit $2,000 into a savings account that pays 7.2% annual interest, compounded annually. If you make no other deposits into the account, how long will it take for the account to contain $3,000?



Keys:	**Display:**	**Description**
■ DISP {FX} 2		Sets display to 2 decimal places.
■ SOLVE {N}	P?*value*	Selects *N*, prompts for *P*.
0 INPUT	I?*value*	Stores *P*, prompts for *I*.
7.2 INPUT	F?*value*	Stores *I*, prompts for *F*.
3000 INPUT	B?*value*	Stores *F*, prompts for *B*.
2000 +/− INPUT	N=5.83	Stores *B*, calculates *N*.

Since the calculated value of N is between 5 and 6, it will take six years of annual compounding to achieve a balance of at least $3,000. The actual balance at the end of six years can be calculated:

■ [SOLVE] {F}	P?0.00	Selects F, prompts for P.
[INPUT]	I?7.20	Retains previous P.
[INPUT]	N?5.83	Retains previous I.
6 [INPUT]	B?-2,000.00	Stores N, prompts for B.
[INPUT]	F=3,035.28	Retains previous B, calculates F.

A

Assistance, Batteries, Memory, and Service

Obtaining Help in Operating the Calculator

We at Hewlett-Packard are committed to providing the owners of HP calculators with ongoing support. You can obtain answers to your questions about using the calculator from our Calculator Support department.

We suggest that you read the next section, "Answers to Common Questions," before contacting us. Past experience has shown that many of our customers have similar questions about our products. If you don't find an answer to your question, you can contact us using the address or phone number listed on the inside back cover.

Answers to Common Questions

Q. How can I determine if the calculator is operating properly?

A. Refer to page 148, which describes the diagnostic self-test.

Q. How do I change the number of decimal places the HP-22S displays?

A. The procedure is described in "Display Mode and Format of Numbers" on page 22.

Q. How do I clear all or portions of memory?

A. [C] clears the current contents of the display. ■ [CLEAR] displays the CLEAR menu, which allows you to clear all of memory, or to selectively clear variables, equations, or statistics registers.

Q. How do I indicate multiplication in an equation?

A. You must use the multiplication sign ([×]). You *cannot* use implied multiplication—for example, AB for A×B.

Q. What does the colon in the display mean?

A. It separates the two numbers entered as n_1 [INPUT] n_2 in statistics or two-argument functions.

Q. My numbers contain commas instead of periods as decimal points. How do I restore the periods?

A. Changing the decimal point is covered in "Interchanging the Period and Comma" on page 25.

Q. What does an "E" in a number (for example, 2.51E-13) mean?

A. The number is displayed in scientific or engineering notation (see page 23).

Q. The calculator has displayed the message MEMORY FULL. What should I do?

A. You must clear a portion of memory before proceeding (see "Clearing Portions of Memory" on page 28).

Q. How can I change the sign of a number?

A. Press [+/-].

Q. Why does calculating the sine of π radians display a very small number instead of 0?

A. π cannot be represented *exactly* with the 12-digit precision of the calculator.The calculated answer is correct for the 12-digit approximation of π.

Q. Why do I get incorrect answers when I use the trigonometric functions?

A. You must make sure you are in the correct angular mode (see page 45.)

Power and Batteries

The calculator is shipped with alkaline batteries. A fresh set of three alkaline batteries provides approximately a year of normal use. However, expected battery life depends on how the calculator is used; frequent, long calculations require more power than short, periodic calculations. For any level of use, mercury and silver oxide batteries last about twice as long as alkaline batteries.

Use only fresh button-cell batteries. Do not use rechargeable batteries. The following batteries are recommended for use. Not all batteries are available in all countries.

Alkaline	**Mercury**	**Silver Oxide**
Panasonic LR44	Panasonic NP675	Panasonic SR44 or SP357
Eveready A76	Eveready EP675E	Eveready 357
Varta V13GA	Toshiba NR44 or MR44	Ray-O-Vac 357
Duracell LR44	Radio Shack NR44 or MR44	Varta V357
	Duracell MP675H	

Low Power Indicator

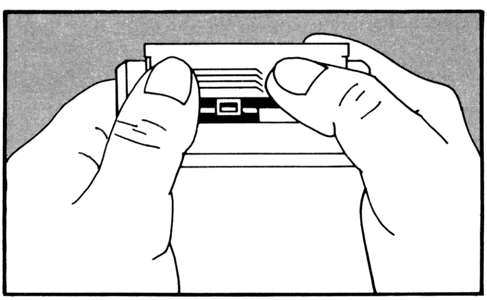
When the low battery annunciator () comes on, you should replace the batteries as soon as possible.

If you continue to use the calculator after the battery annunciator comes on, power can eventually drop to a level at which the display becomes dim, and stored data may be affected. If this happens, the calculator requires fresh batteries before it will operate properly. If stored data has not been preserved due to extremely low power, the HP-22S displays MEMORY CLEAR.

Installing Batteries

Once the batteries are removed, you must replace the batteries within one minute to prevent loss of Continuous Memory. Therefore, you should have the new batteries readily at hand before removing the batteries. Also, you must make sure the calculator is off during the entire process of changing batteries.

1. Have three fresh button-cell batteries at hand.
2. Make sure the calculator is *off.* **Do not press [C] again until the entire procedure for changing batteries is completed. Changing batteries with the calculator on will erase the contents of Continuous Memory.**
3. Hold the calculator as shown. To remove the battery-compartment door, press down and outward on it until it slides off (away from the center).



4. Turn the calculator over and shake the batteries out.

Warning

Do not mutilate, puncture, or dispose of batteries in fire. The batteries can burst or explode, releasing hazardous chemicals.

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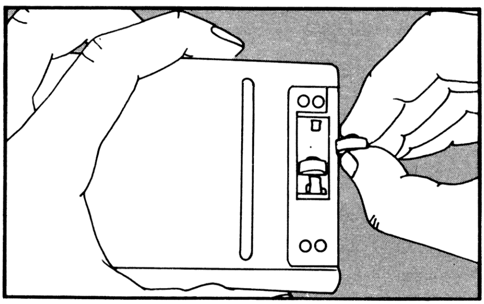
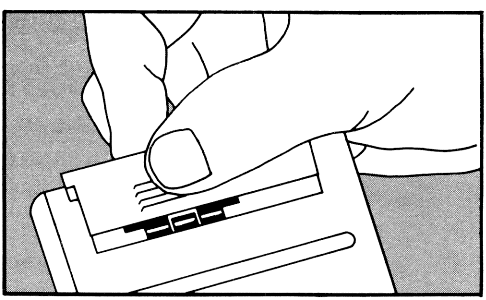
5. Hold the calculator as shown and stack the batteries, one at a time, in the battery compartment. Orient the batteries according to the diagram inside the battery compartment. Be sure the raised and flat ends match the diagram.



6. Insert the tab of the battery-compartment door into the slot in the calculator case, as shown.



Now turn the calculator back on. If it does not function, you might have taken too long to change the batteries or inadvertently turned the calculator on while the batteries were out. *Remove the batteries* again and lightly press a coin against both battery contacts in the calculator *for a few seconds.* Put the batteries back in and turn the calculator on. It should display `MEMORY CLEAR`.

Managing Calculator Memory

The HP-22S has approximately 371 bytes (units) of calculator memory available for your use.

The calculator displays `MEMORY FULL` if you attempt an operation that uses more calculator memory than is currently available. Whenever the message is displayed, you must reduce the amount of occupied memory. You can:

- Clear any variables you no longer need (see page 40).
- Clear any equations you no longer need (see page 74).
- Clear the statistical registers (see page 62).

Memory Requirements

Type of Information	Amount of Memory Used
Variables	8 bytes per non-zero value.
Equations	For each equation: 1 byte + 1 byte for each digit, variable, operator, or function. (Library equations do not require memory.)
Statistical data	48 bytes.
Calculations	8½ bytes per number + ½ byte per operator.

Resetting the Calculator

If the calculator doesn't respond to keystrokes or if it is otherwise behaving unusually, you should attempt to reset it. Resetting the calculator halts the current calculation and clears the display. Stored data usually remains intact.

To reset the calculator, hold down the [C] key and press [LN]. If you are unable to reset the calculator, try installing fresh batteries. If the calculator cannot be reset, or if it still fails to operate properly, you should attempt to clear memory using the procedure described in the next section.

Clearing Memory

If the calculator fails to respond to keystrokes, and you are unable to restore operation by resetting it or changing the batteries, do the following procedure. These keystrokes clear user memory (like ■ [CLEAR] {ALL}), and may be possible when the keyboard is not functioning properly:

1. Press and hold down the [C] key.
2. Press and hold down [$\sqrt{x}$].
3. Press [$\Sigma+$]. (You will be pressing three keys simultaneously.)

The HP-22S displays MEMORY CLEAR if the operation is successful, and these start-up conditions are set: period decimal point, FIX 4 display modes, decimal base, and Degrees mode.

Memory may inadvertently be cleared if the calculator is dropped or if power is interrupted.

Environmental Limits

In order to maintain product reliability, you should observe the following temperature and humidity limits of the HP-22S:

- Operating temperature: 0° to 45°C (32° to 113°F).
- Storage temperature: −20° to 65°C (−4° to 149°F).
- Operating and storage humidity: 90% relative humidity at 40°C (104°F) maximum.

Determining If the Calculator Requires Service

Use these guidelines to determine if the calculator requires service. Then, if necessary, read "If the Calculator Requires Service" on page 151.

- **If the calculator won't turn on (nothing is visible in the display):**
  1. Attempt to reset the calculator (see page 146).
  2. If the calculator fails to respond after step 1, replace the batteries (see page 143).

  If steps 1 and 2 fail to restore calculator function, it requires service.
- **If the calculator doesn't respond to keystrokes (nothing happens when you press any of the keys):**
  1. Attempt to reset the calculator (see page 146).
  2. If the calculator fails to respond after step 1, attempt to clear memory (see page 146). This will erase all the information you've stored.

3. If the calculator fails to respond after steps 1 and 2, remove the batteries (see page 143) and lightly press a coin against both calculator battery contacts. Put the batteries back in and turn on the calculator. It should display `MEMORY CLEAR`.

If steps 1 through 3 fail to restore calculator function, the calculator requires service.

- **If the calculator responds to keystrokes but you suspect that it is malfunctioning:**

  1. Do the self-test (described below). If the calculator fails the self test, it requires service.
  2. If the calculator passes the self-test, it is likely that you've made a mistake in operating the calculator. Try rereading portions of the manual, and check "Answers to Common Questions" on page 140.
  3. Contact the Calculator Support department. The address and phone number are listed on the inside back cover.

Confirming Calculator Operation—the Self-Test

If the display can be turned on, but it appears that the calculator is not operating properly, you can do a diagnostic self-test.

1. To start the self-test, hold down the [C] key while you press [y^x].*
2. Press any key eight times, and watch the display as various patterns are displayed. After you've pressed the key eight times, the calculator displays the copyright message `COPR. HP 1987`, and then the message `KBD 01`.

* Holding down [C] as you press [1/x] starts a continuous self-test that is used at the factory. If you accidently start this self-test, you can halt it by pressing any key.

3. Starting at the upper left corner ([√x]) and moving from left to right, press each key in the top row. Then, moving left to right, press each key in the second row, third row, etc., until you've pressed each key.
   - If you press the keys in the proper order, and they are functioning properly, the calculator displays KBD followed by two-digit numbers. (The calculator is counting the keys using hexadecimal base.)
   - If you press a key out of order, or if a key isn't functioning properly, the next keystroke displays a fail message (see step 4).
4. The self-test produces one of these two results:
   - The calculator displays 22S - OK if it passed the self-test. Go to step 5.
   - The calculator displays 22S - FAIL followed by a one-digit number, if it failed the self-test. If you received the message because you pressed a key out of order, you should reset the calculator (hold down [C] and press [LN]) and do the self-test again. If you pressed the keys in order, but got this message, repeat the self-test to verify the results. If the calculator fails again, it requires service (see page 151). Include a copy of the fail message with the calculator when you ship it for service.
5. To exit the self-test, reset the calculator (hold down [C] and press [LN]).

Limited One-Year Warranty

What Is Covered

The calculator (except for the batteries, or damage caused by the batteries) *is warranted by Hewlett-Packard against defects in materials and workmanship for one year from the date of original purchase.* If you sell your unit or give it as a gift, the warranty is automatically transferred to the new owner and remains in effect for the original one-year period. During the warranty period, we will repair or, at our option, replace at no charge a product that proves to be defective, provided you return the product, shipping prepaid, to a Hewlett-Packard service center. (Replacement may be with a newer model of equivalent or better functionality.)

This warranty gives you specific legal rights, and you may also have other rights that vary from state to state, province to province, or country to country.

What Is Not Covered

Batteries, and damage caused by the batteries, are not covered by the Hewlett-Packard warranty. Check with the battery manufacturer about battery and battery leakage warranties.

This warranty does not apply if the product has been damaged by accident or misuse or as the result of service or modification by other than an authorized Hewlett-Packard service center.

No other express warranty is given. The repair or replacement of a product is your exclusive remedy. **ANY OTHER IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS IS LIMITED TO THE ONE-YEAR DURATION OF THIS WRITTEN WARRANTY.** Some states, provinces, or countries do not allow limitations on how long an implied warranty lasts, so the above limitation may not apply to you. **IN NO EVENT SHALL HEWLETT-PACKARD COMPANY BE LIABLE FOR CONSEQUENTIAL DAMAGES.** Some states, provinces, or countries do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

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

Consumer Transactions in the United Kingdom

This warranty shall not apply to consumer transactions and shall not affect the statutory rights of a consumer. In relation to such transactions, the rights and obligations of Seller and Buyer shall be determined by statute.

If the Calculator Requires Service

Hewlett-Packard maintains service centers in many countries. These centers will repair a calculator, or replace it with the same model or one of equal or greater value, whether it is under warranty or not. There is a service charge for service after the warranty period. Calculators normally are serviced and reshipped within 5 working days.

Obtaining Service

- **In the United States:** Send the calculator to the Calculator Service Center listed on the inside of the back cover.
- **In Europe:** Contact your HP sales office or dealer, or HP's European headquarters for the location of the nearest service center. *Do not ship the calculator for service without first contacting a Hewlett-Packard office.*

  Hewlett-Packard S.A.
  150, Route du Nant-d'Avril
  P.O. Box CH 1217 Meyrin 2
  Geneva, Switzerland
  Telephone: (022) 82 81 11

- **In other countries:** Contact your HP sales office or dealer or write to the U.S. Calculator Service Center (listed on the inside of the back cover) for the location of other service centers. If local service is unavailable, you can ship the calculator to the U.S. Calculator Service Center for repair.

  All shipping, reimportation arrangements, and customs costs are your responsibility.

Service Charge

There is a standard repair charge for out-of-warranty service. The Calculator Service Center (listed on the inside of the back cover) can tell you how much this charge is. The full charge is subject to the customer's local sales or value-added tax wherever applicable.

Calculator products damaged by accident or misuse are not covered by the fixed service charges. In these cases, charges are individually determined based on time and material.

Shipping Instructions

If your calculator requires service, ship it to the nearest authorized service center or collection point. (You must pay the shipping charges for delivery to the service center, whether or not the calculator is under warranty.) Be sure to:

- Include your return address and description of the problem.
- Include proof of purchase date if the warranty has not expired.
- Include a purchase order, check, or credit card number plus expiration date (Visa or MasterCard) to cover the standard repair charge. In the United States and some other countries, the serviced calculator will be returned C.O.D. if you do not pay in advance.
- Ship the calculator in adequate protective packaging to prevent damage. Such damage is not covered by the warranty, so we recommend that you insure the shipment.

Warranty on Service

Service is warranted against defects in materials and workmanship for 90 days from the date of service.

Service Agreements

In the U.S., a support agreement is available for repair and service. Refer to the form in the front of the manual. For additional information, contact the Calculator Service Center (see the inside of the back cover).

Regulatory Information

Radio Frequency Interference

U.S.A. The HP-22S generates and uses radio frequency energy and may interfere with radio and television reception. The calculator complies with the limits for a Class B computing device as specified in Subpart J of Part 15 of FCC Rules, which provide reasonable protection against such interference in a residential installation. In the unlikely event that there is interference to radio or television reception (which can be determined by turning the HP-22S off and on or by removing the batteries), try:

- Reorienting the receiving antenna.
- Relocating the calculator with respect to the receiver.

For more information, consult your dealer, an experienced radio/television technician, or the following booklet, prepared by the Federal Communications Commission: *How to Identify and Resolve Radio-TV Interference Problems*. This booklet is available from the U.S. Government Printing Office, Washington, D.C. 20402, Stock Number 004-000-00345-4. At the first printing of this manual, the telephone number was (202) 783-3238.

West Germany. The HP-22S complies with VFG 1046/84, VDE 0871B, and similar non-interference standards. If you use equipment that is not authorized by Hewlett-Packard, that system configuration has to comply with the requirements of Paragraph 2 of the German Federal Gazette, Order (VFG) 1046/84, dated December 14, 1984.

B

More About Solving Equations

[SOLVE] uses an iterative process that searches for a number that sets the left side of the equation equal to the right side. A convenient way to conceptualize the process is to think of the equation as a function of one variable, the *unknown*, for which [SOLVE] is seeking a *root*. The root of a function is a number that sets the value of the function equal to 0. For convenience, this appendix will consistently use x as the unknown.

How [SOLVE] Finds a Root

Consider an equation containing a number of variables, including unknown x. When values have been entered for all variables except the unknown, the equation has the form:

$$g(x) = h(x)$$

where $g(x)$ and $h(x)$ are the left and right sides of the equation. For example, when the equation:

$$ax^3 + \frac{b}{r}x^2 = \frac{1}{4}cx + d$$

is solved for x with $a=-2$, $b=8$, $r=2$, $c=24$, and $d=-8$, it has the form:

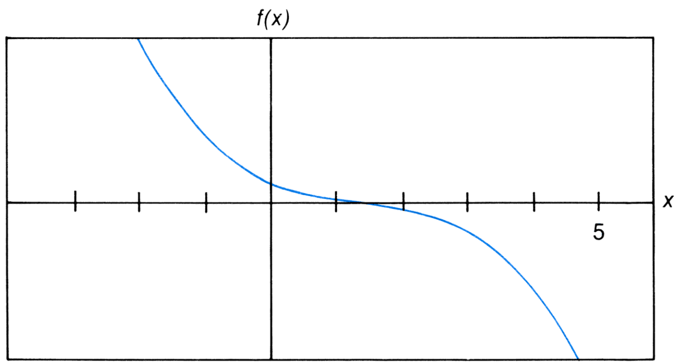
$$\underbrace{-2x^3 + 4x^2}_{\text{g(x)}} = \underbrace{6x - 8}_{\text{h(x)}}$$

Since $g(x) - h(x) = 0$, the equation can be rewritten:

$$f(x) = g(x) - h(x) = -2x^3 + 4x^2 - 6x + 8 = 0$$

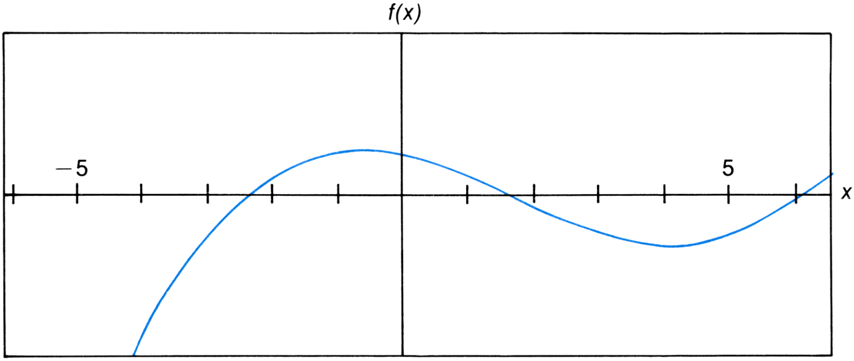
The value of x for which $f(x) = 0$ is called a *root* of the equation. SOLVE seeks a root for $f(x)$ by evaluating the function repeatedly at estimates of x, and comparing the results to previous estimates. Using an complicated algorithm, SOLVE intelligently chooses a new estimate where the graph might cross the x-axis.

The graph of the function $f(x) = -2x^3 + 4x^2 - 6x + 8$ illustrates that the function has one root. (The example on page 159 calculates this root.)



$f(x) = -2x^3 + 4x^2 - 6x + 8$

The function $f(x) = x^3 - 5x^2 - 10x + 20$ has three roots.



$f(x) = x^3 - 5x^2 - 10x + 20$

All three roots can be found by entering appropriate guesses for x. To help select guesses, you can get some idea of the behavior of the function by evaluating $f(x)$ at various values of x.

SOLVE's Ability To Find a Root

If any two estimates yield $f(x)$ with opposite signs, SOLVE presumes that $f(x)$ crosses the x-axis in at least one place between the two estimates. The interval is systematically narrowed until a root is found.

For SOLVE to find a root, the root has to exist within the range of numbers of the calculator, and $f(x)$ must be defined in the domain where the iterative search occurs. SOLVE always finds a root if one or more of these conditions are met:

- Two estimates yield $f(x)$ values with opposite signs, and the function's graph crosses the x-axis in at least one place between those estimates (figure B-1a).
- $f(x)$ always increases or decreases as x is increased (figure B-1b).
- The graph of $f(x)$ is either concave or convex everywhere (figure B-1c).
- If $f(x)$ has one or more local minima and maxima, each occurs singly between adjacent zeros of $f(x)$ (figure B-1d).

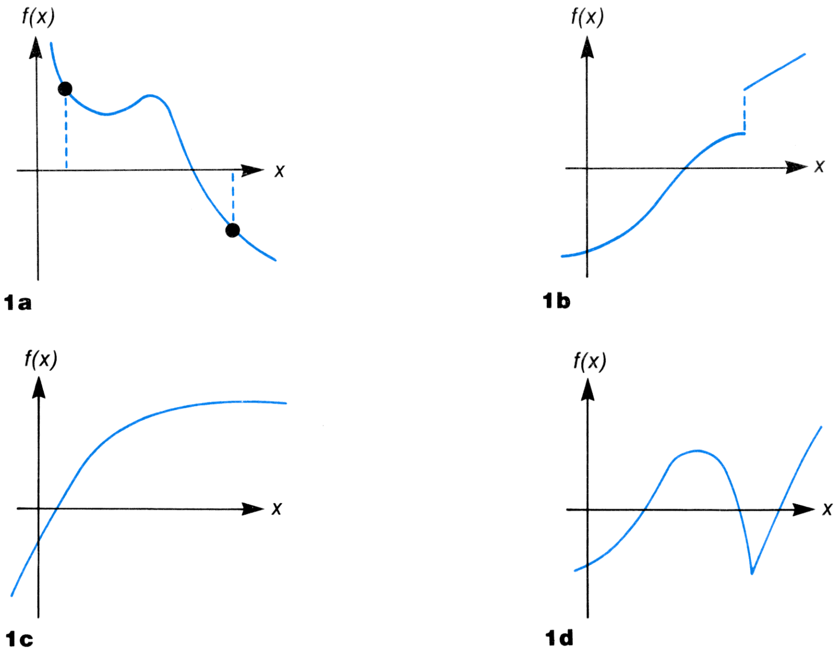


Figure B-1. Functions for Which a Root Can be Found

In most situations, the calculated root is an accurate estimate of the theoretical, infinitely precise root of the equation. An "ideal" solution is one for which $f(x)=0$. However, a non-zero value for $f(x)$ is often also acceptable because it results from approximating numbers with limited (12-digit) precision.

Interpreting Results

SOLVE will display an answer:

- If it finds an estimate for which $f(x)$ equals 0 (see figure B-2a).
- If it finds an estimate where $f(x)$ is not equal to 0, but the calculated root is a 12-digit number adjacent to the place where the function's graph crosses the x-axis (see figure B-2b). This occurs when the two final estimates are neighbors (that is, they differ by 1 in the 12th digit), and the function's value is positive for one estimate and negative for the other. In *most* cases, $f(x)$ will be relatively close to 0.

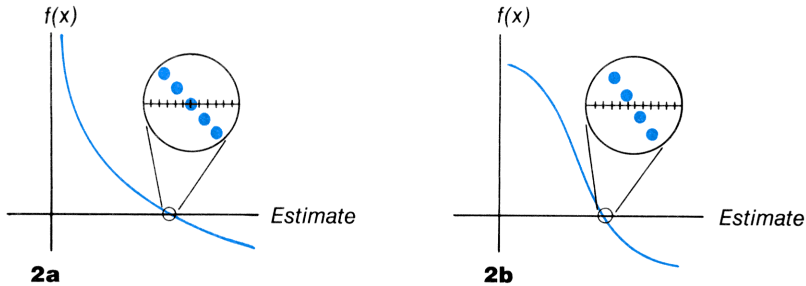


Figure B-2. Cases Where a Root is Found

To obtain additional information about the result, press ■ LAST to see the value of *f(x)* (the value of the left side of the equation minus the value of the right side of the equation). If *f(x)* equals 0 or is relatively small, it is very likely that SOLVE has found a solution. However, if *f(x)* is relatively large, you must use judgment in interpreting the results.

Example: A Solution With One Root. Find the root of the equation:

$$-2x^3 + 4x^2 - 6x + 8 = 0$$

SOLVE Equation: `-2×X^3+4×X^2-6×X+8=0`

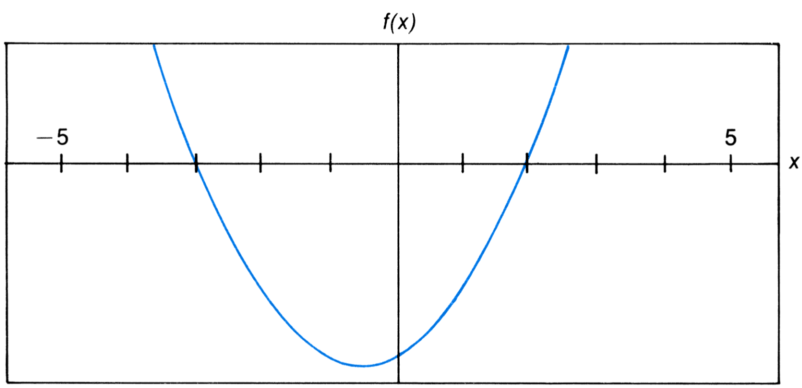
Keys:	**Display:**	**Description:**
0 STO X 10 ■ SOLVE	X=1.6506	Calculates x using guesses 0 and 10.
■ LAST	-4.0000E-11	*f(x)* is *very* small.

Example: An Equation With Two Roots. Find the roots of the equation:

$$x^2 + x - 6 = 0$$

SOLVE Equation: `X^2+X-6=0`

Keys:	Display:	Description:
0 [STO] X 10 ■ [SOLVE]	X=2.0000	Calculates the positive root using guesses 0 and 10.
■ [LAST] ■ [SHOW]	0.00000000000	$f(x) = 0$.
0 [STO] X 10 [+/-] ■ [SOLVE]	X=-3.0000	Calculates the negative root using guesses 0 and -10.
■ [LAST] ■ [SHOW]	0.00000000000	$f(x) = 0$.



$f(x) = x^2 + x - 6$

Certain cases require special consideration:

- If the function's graph has a discontinuity that crosses the x-axis, [SOLVE] returns a value adjacent to the discontinuity (see figure B-3a). In this case, $f(x)$ may be relatively large.
- Values of $f(x)$ may be approaching infinity at the location where the graph changes sign (see figure B-3b). This situation is called a *pole*. Since [SOLVE] determines that there is a sign change between two neighboring values of x, it returns the possible root. However, the value in ■ [LAST] will be relatively large. If the pole occurs at a value of x that is exactly represented with 12 digits, [SOLVE] may try that value and halt with an error message.

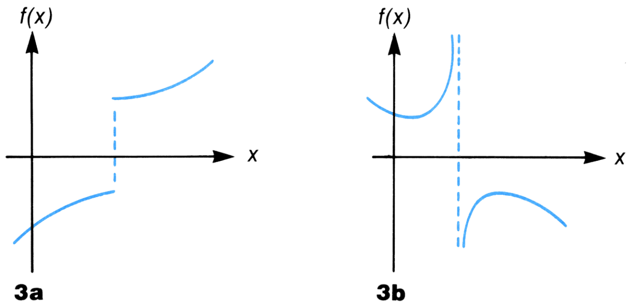


Figure B-3. Special Cases

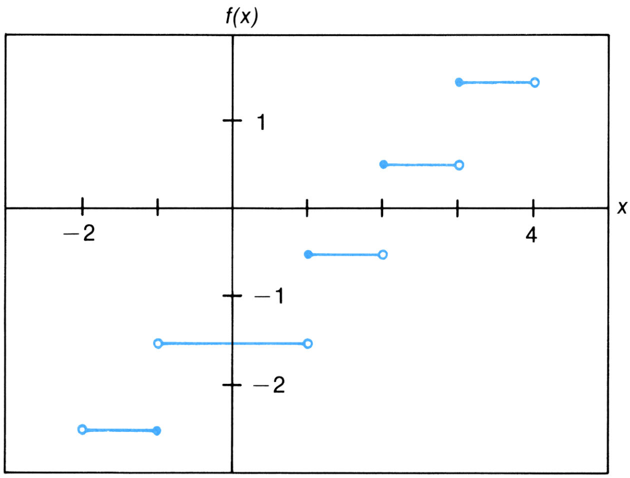
Example: A Discontinuous Function. Find the root of the equation:

$$\mathrm{IP}(x) - 1.5 = 0$$

SOLVE Equation: `IP(X)-1.5=0`

Keys:	**Display:**	**Description:**
0 STO X 5 ■ SOLVE	`X=2.0000`	SOLVE finds a root with guesses 0 and 5.
■ LAST	`0.5000`	*f(x)* is relatively large.

Note the relatively large value for $f(x)$. There is no value of x for which $f(x)$ equals 0. However, at $x=2.0000$, SOLVE finds two neighboring values of x that yield opposite signs for $f(x)$.



$f(x) = \mathrm{IP}(x) - 1.5 = 0$

Example: A Pole. Find the root of the equation:

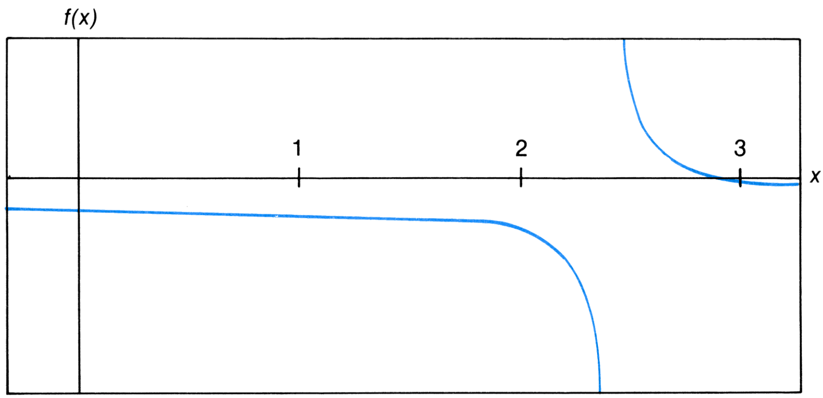
$$\frac{x}{x^2 - 6} - 1 = 0$$

SOLVE Equation: `X÷(X^2-6)-1=0`

As x approaches $\sqrt{6}$, $f(x)$ becomes a very large positive or negative number:

Keys:	**Display:**	**Description:**
2.3 STO X 2.7 ■ SOLVE	`X=2.4495`	Calculates the root using guesses that bracket $\sqrt{6}$.
■ LAST	`81,649,658,092.0`	$f(x)$ is relatively large.

The function's graph illustrates the pole between the final estimates. The initial guesses yielded opposite signs for *f(x)*. SOLVE narrowed the interval between successive estimates until two neighbors were found. The function has roots at -2 and 3, which can be found by entering appropriate guesses.



$$f(x) = \frac{x}{x^2 - 6} - 1$$

When SOLVE Cannot Find a Root

There are a number of reasons that SOLVE may fail to find a root. The following conditions result in the message `NO ROOT FND`:

- The search may terminate at a local minimum or maximum (see figure B-4a). If the value of *f(x)* stored in LAST is relatively close to 0, it is possible that a root has been found; the number stored in the unknown variable may be a 12-digit number very close to a theoretical root.
- The search may halt because SOLVE is working on a horizontal asymptote—an area where *f(x)* is essentially constant for a wide range of *x* (see figure B-4b). The number stored in LAST is the value of the potential asymptote.
- The search may be concentrated in a local "flat" region of the function (see figure B-4c). The number stored in LAST is the value of the function in this region.

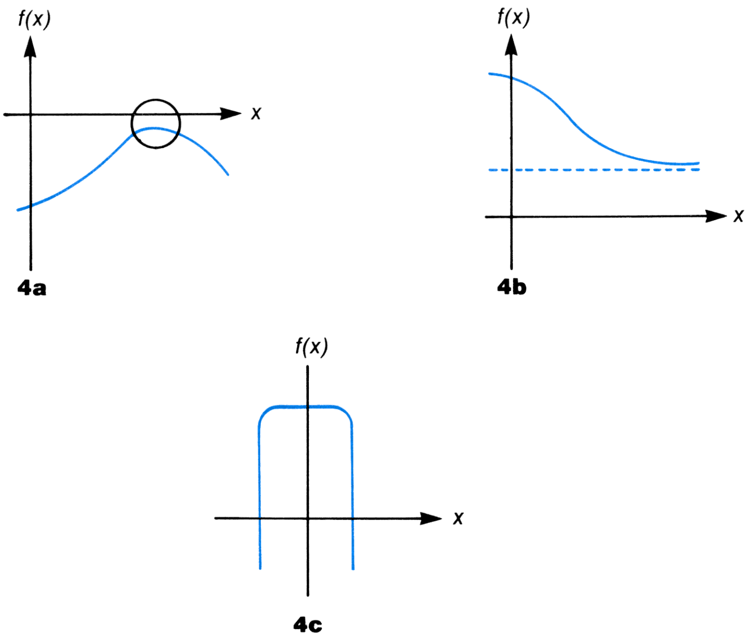


Figure B-4. Conditions Where SOLVE Can't Find a Root

In addition to the NO ROOT FND error, SOLVE may return a math error if an estimate produces an unallowed operation—for example, division by 0, square root of a negative number, or logarithm of 0. You should keep in mind that SOLVE can generate estimates over a wide range. You can sometimes avoid math errors by using very good guesses. If SOLVE returns a math error, press RCL *unknown variable* to see the value that produced the error.

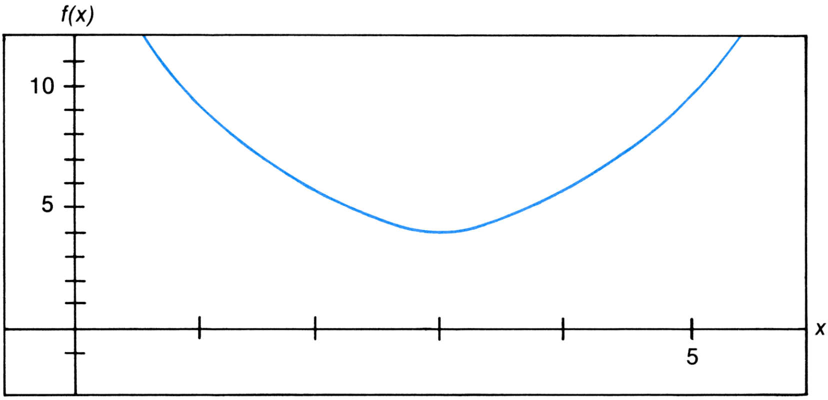
Example: A Relative Minimum. Calculate the root of the equation:

$$x^2 - 6x + 13 = 0$$

SOLVE Equation: `X^2-6×X+13=0`

Keys:	**Display:**	**Description:**
0 [STO] X 10 ■ [SOLVE]	`NO ROOT FND`	Search fails with guesses 0 and 10.
[C]	`3.0000`	Displays the last estimate of x.
■ [LAST]	`4.0000`	Value of $f(x)$ at $x = 3$.

The function is a parabola with a minimum at coordinate (3,4). You could obtain your own rough sketch of the function by evaluating $f(x)$ using various values of x in the vicinity of $x = 3$. (To evaluate $f(x)$, edit the equation to the expression `X^2-6×X+13`, and use [EVAL] to calculate the value of the expression for various x-values.)



$f(x) = x^2 - 6x + 13$

Example: An Asymptote. Find the root for the equation:

$$10 - \frac{1}{x} = 0$$

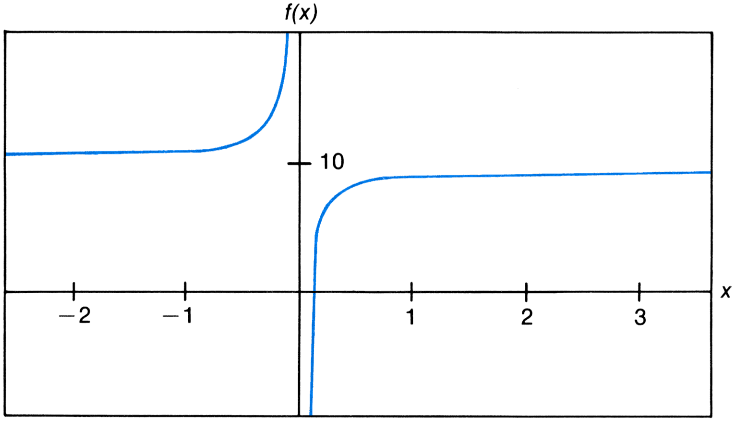
SOLVE Equation: `10-INV(X)=0`

Keys:	**Display:**	**Description:**
.005 [STO] X 5 ■ [SOLVE]	`X=0.1000`	Calculates x using guesses .005 and 5.
■ [LAST] ■ [SHOW]	`0.00000000000`	$f(x) = 0.$

Watch what happens when you use negative values for guesses:

Keys:	**Display:**	**Description:**
1 [+/-] [STO] X 2 ■ [SOLVE]	`NO ROOT FND`	
[C]	`-46,666,666,692.1`	Displays last estimate of x.
■ [LAST]	`10.0000`	$f(x)$ for last estimate.

The graph illustrates that $f(x)$ approaches 10 as x becomes a large negative number.



$f(x) = 10 - \text{INV}(x)$

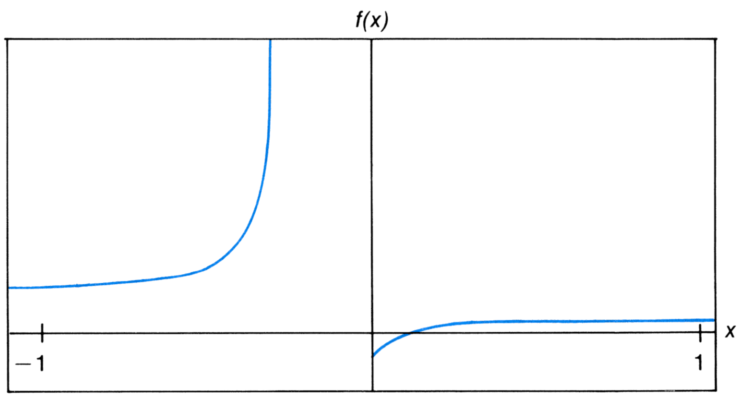
Example: A Math Error. Find the root of the equation:

$$\sqrt{\frac{x}{x + .3}} - .5 = 0$$

SOLVE Equation: `SQRT(X÷(X+.3))-.5=0`

Keys:	**Display:**	**Description:**
First, attempt to find a positive root.		
0 [STO] X 10 ■ [SOLVE]	`X=0.1000`	Calculates the root using guesses 0 and 10.
Now, attempt to find a negative root by entering guesses 0 and −10.		
0 [STO] X 10 [+/-] ■ [SOLVE]	`SQRT(NEG)`	Math error.
[RCL] X	`X=-0.2381`	Displays the final estimate of x.

The function is undefined for values of x between 0 and −0.3 since those values produce a negative square root.



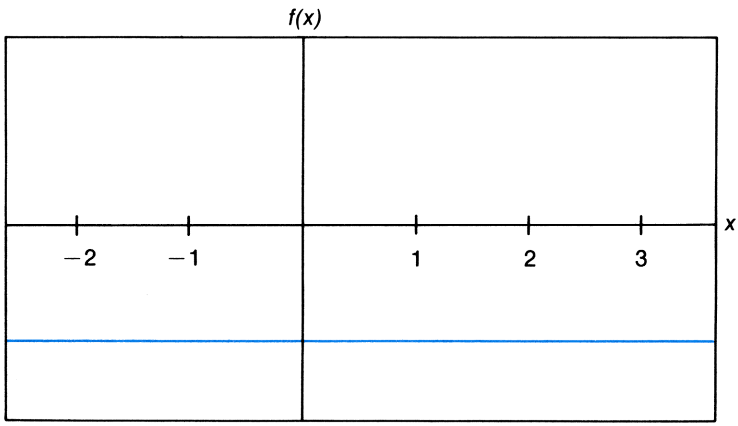
$$f(x) = \sqrt{\frac{x}{x + .3}} - .5$$

Example: A Local "Flat" Region. Find the root of the equation:

$$x - 1 \times 10^{100} = 0$$

SOLVE Equation: `X-1E100=0`

Keys:	Display:	Description:
1 [STO] X 2 [■] [SOLVE]	`NO ROOT FND`	No root found using guesses 1 and 2.
[C]	`2.0000`	Displays final estimate of x.
[■] [LAST]	`-1.0000E100`	Value of $f(x)$ at $x=2$.
1 [+/-] [STO] X 2 [+/-] [■] [SOLVE]	`NO ROOT FND`	No root found.
[C] [■] [LAST]	`-2.0000` `-1.0000E100`	Final estimate and $f(x)$.



$f(x) = x - 1 \times 10^{100}$

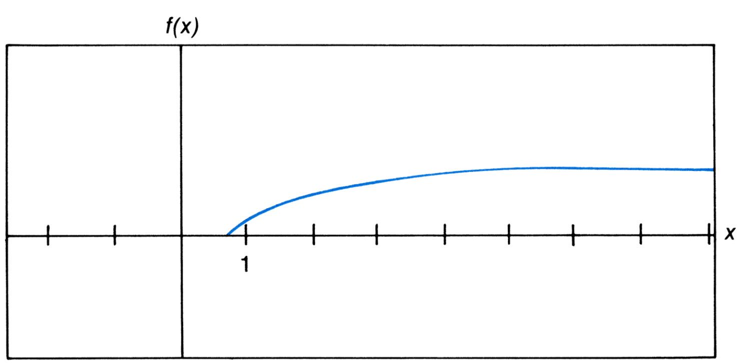
Example: Using Good Guesses To Find a Solution. Find the root of the equation:

$$\sqrt{x + \ln x} - .5 = 0$$

SOLVE Equation: `SQRT(X+LN(X))-.5=0`

Notice that x must be greater than 0 to avoid an error due to the `LN` function.

Keys:	**Display:**	**Description:**
Attempt to find a positive root with guesses 1 and 5.		
1 [STO] X 5 ■ [SOLVE]	`LOG(NEG)`	Math error.
[RCL] X	`X=-0.2732`	[SOLVE] found no root between 1 and 5, and tried a negative x.
See what happens when you use very good guesses.		
.6 [STO] X .7 ■ [SOLVE]	`X=0.6622`	[SOLVE] finds a root.
■ [LAST]	`-1.0000E-12`	$f(x)$ is very small.



$$f(x) = \sqrt{x + \ln x} - .5$$

Round-Off Error and Underflow

Round-Off Error. The limited (12-digit) precision of the calculator can cause "round-off" errors that adversely affect iterative solutions. For example:

$$[(|x| + 1) + 10^{15}]^2 - 10^{30} = 0$$

has no roots because the left side of the equation is always positive. However, SOLVE returns the answer 2.0000 for initial guesses of 1 and 2, due to round-off.

Round-off can also cause SOLVE to fail to find a root. The equation:

$$\mathrm{ABS}(x^2 - 7) = 0$$

has a root at $\sqrt{7}$. However, no 12-digit number *exactly* equals $\sqrt{7}$, so the function never equals 0. Furthermore, the function never changes sign. SOLVE returns the message `NO ROOT FND`.

Underflow. Underflow can also affect SOLVE results. For example, consider the equation:

$$\frac{1}{x^2} = 0$$

whose root is infinite in value. Because of underflow, SOLVE returns a very large value as a root.

C

Equations Used by HP-22S Functions

General Functions

$$Cn,r = \frac{n!}{r!\,(n - r)\,!} \qquad Pn,r = \frac{n!}{(n - r)\,!}$$

$$x = r\ cos\ \theta \qquad y = r\ sin\ \theta$$

$$r = \sqrt{x^2 + y^2} \qquad tan\ \theta = \frac{y}{x} \qquad -180 < 0 \leqslant 180°$$

$$\%\mathrm{CHG} = \frac{number_2 - number_1}{number_1} \times 100$$

Statistical Functions

$$\bar{x} = \frac{\Sigma x_i}{n} \qquad \bar{y} = \frac{\Sigma y_i}{n}$$

$$\bar{x}w = \frac{\Sigma y_i x_i}{\Sigma y_i}$$

$$sx = \sqrt{\frac{\Sigma(x_i - \bar{x})^2}{n - 1}} \qquad sy = \sqrt{\frac{\Sigma(y_i - \bar{y})}{n - 1}}$$

$$r = \frac{\Sigma(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\Sigma(x_i - \bar{x})^2 \; \Sigma(y_i - \bar{y})^2}}$$

$$m = \frac{\Sigma(xi - \bar{x})\;(yi - \bar{y})}{\Sigma(xi - \bar{x})^2}$$

$$b = \bar{y} - m\bar{x}$$

Messages

ALL VARS=0
All variables equal 0.

CALCULATING
The HP-22S is calculating a result.

DIVIDE BY 0
Attempt to divide by zero.

INPUT 2 NUMS
Attempt to execute a function that requires two arguments without keying in both arguments.

INTERRUPTED
An [EVAL] or [SOLVE] calculation has been interrupted.

INVALID DATA
Data error:

- Attempt to calculate combinations or permutations with r>n, or with non-integer *r* or *n*.
- Attempt to use a trigonometric or hyperbolic function with an unallowed argument.
- [EVAL] has generated a value greater than ±1E500.

INVALID EQN
A syntax error has occurred during equation entry. (See "The Syntax of Equations" on page 78.)

INVALID n!

Attempt to calculate the factorial of a negative or non-integer value.

INVALID Y^x

Exponentiation error:

- Attempt to raise 0 to the 0th or to a negative power.
- Attempt to raise a negative number to a non-integer power.

LIBRARY EQN

Attempt to edit a library equation.

LOG(0)

Attempt to take the base 10 or natural log of zero.

LOG(NEG)

Attempt to take the base 10 or natural log of a negative number.

MEMORY CLEAR

All of user memory has been erased (see pages 28 and 146).

MEMORY FULL

The calculator has insufficient memory available to do the operation.

NO ROOT FND

SOLVE cannot solve the equation using the current initial guesses (see page 87).

NO STAT DATA

Attempt to do a statistics calculation with no statistics data stored (see "Entering Statistical Data" on page 60).

NO VARS USED

Attempt to do a SOLVE calculation with an equation that has no variables.

OVERFLOW

Warning (displayed momentarily); the magnitude of a result is too large for the calculator to handle. The HP-22S returns ±9.99999999999E499 in the current display format. (See "Range of Numbers" on page 27.)

SELECT EQN

Attempt to do an [EVAL] or [SOLVE] calculation without selecting an equation.

SOLVING

[SOLVE] is calculating a result.

SQRT(NEG)

Attempt to calculate the square root of a negative number.

STAT ERROR

Statistics error:

- Attempt to calculate *sx*, *sy*, $\hat{x}$, $\hat{y}$, *m*, *r*, or *b* with $n = 1$.
- Attempt to calculate *r*, $\hat{x}$, or $\bar{x}w$ with *x*-data only (all *y*-values equal to 0).
- Attempt to calculate *r* with all *y*-values equal.
- Attempt to calculate $\hat{x}$, $\hat{y}$, *r*, *m*, or *b* with all *x*-values equal.
- Attempt to do a statistics calculation after [Σ-] has reduced *n* to 0.

TOO BIG

The magnitude of the number is too large to be converted to hexadecimal, octal, or binary base. The number must be in the range $-34{,}359{,}738{,}368 \leqslant n \leqslant 34{,}359{,}738{,}367$.

TYPE NEW EQN

You can type a new equation into the list of equations.

Function Index

Function	Keys and Description	Page
+/−	[+/−] Change sign.	14
■	Shift key. Activates shifted functions (functions printed in blue).	16
. (period)	■ [MODES] { . } Sets period as the decimal point.	25
, (comma)	■ [MODES] { , } Sets comma as the decimal point.	25
: (colon)	■ [:] Used in equations to separate arguments of two-argument functions.	73
◆	[◆] Backspace; in digit entry, deletes the last digit keyed in; otherwise, clears the current display contents.	15
▲	■ [▲] Displays previous entry in the list of equations, library list, or variables catalog.	74
▼	[▼] Displays next entry in the list of equations, library list, or variables catalog.	74
$^1/_x$	[1/x] Reciprocal.	43
10^x	■ [10^x] Common antilogarithm (10 to the power of the displayed number).	42

Function	Keys and Description	Page
%	■ [%] Divides displayed number n by 100 (n ■ [%], $n_1 \times n$ ■ [%], $n_1 \div n$ ■ [%]), or calculates n% of n_1 ($n_1 + n$ ■ [%], $n_1 - n$ ■ [%]).	43
%CHG	■ [%CHG] Percent change between numbers n_1 and n_2, entered as n_1 [INPUT] n_2.	44
π	■ [π] Displays π (3.14159265359) in current display format.	44
$\Sigma+$	[Σ+] Accumulates x- and y-values into statistics registers.	60
$\Sigma-$	[Σ-] Removes x- and y-values from the statistics registers.	61
Σx	[STAT] {Σ} {x} Sum of the x statistical data.	62
Σx^2	[STAT] {Σ} {x²} Sum of the squares of the x statistical data.	62
Σxy	[STAT] {Σ} {xy} Sum of the products $x \times y$ for the statistical data.	62
Σy	[STAT] {Σ} {y} Sum of the y statistical data.	62
Σy^2	[STAT] {Σ} {y²} Sum of the squares of the y statistical data.	62
ABS	■ [PARTS] {ABS} Absolute value.	52
ACOS	■ [ACOS] Arc cosine.	45
ACOSH	■ [HYP] ■ [ACOS] Hyperbolic arc cosine.	51
ALL	■ [DISP] {ALL} Displays all non-zero digits.	25
ANGLE	■ [ANGLE] Coordinate conversions; stores or calculates the θ polar coordinate.	48

Function	Keys and Description	Page
ASIN	■ [ASIN] Arc sine.	45
ASINH	■ [HYP] ■ [ASIN] Hyperbolic arc sine.	51
ATAN	■ [ATAN] Arc tangent.	45
ATANH	■ [HYP] ■ [ATAN] Hyperbolic arc tangent.	51
b	[STAT] {L.R.} {b} *y*-intercept of line computed by linear regression.	63
BASE	■ [BASE] Displays the menu for changing the number base.	54
BN	■ [BASE] {BN} Sets binary (base 2) mode.	54
→°C	■ [UNITS] {TMP} {→°C} Converts degrees Fahrenheit to degrees Celsius.	53
Clear/cancel	[C] Clears current display contents; cancels current menu.	15
Clear Σ	■ [CLEAR] {Σ} Clears the statistical registers.	62
Clear ALL	■ [CLEAR] {ALL} Clears all stored data and equations.	28
Clear EQ	■ [CLEAR] {EQ} Clears all equations in the equation list.	28
Clear VAR	■ [CLEAR] {VAR} Clears variables *A* through *Z*.	40
→CM	■ [UNITS] {L} {→CM} Converts inches to centimeters.	53
Cn,r	■ [PROB] {Cn,r} Combinations of *n* objects taken *r* at a time.	50
COS	[COS] Cosine	45
COSH	■ [HYP] [COS] Hyperbolic cosine.	51

Function	Keys and Description	Page
DEC	■ BASE {DEC} Sets decimal (base 10) mode.	54
D↔RAD	■ D↔RAD Displays degrees/radians conversion menu.	46
→DEG	■ D↔RAD {→DEG} Converts angle in radians to degrees.	46
DG	■ MODES {DG} Sets Degrees angular mode.	45
DISP	■ DISP Displays menu for changing display format.	23
E	■ E Begins exponent for exponential notation.	25
EDIT	■ EDIT Turns on cursor at the end of selected equation in list of equations.	74
EN	■ DISP {EN} Selects engineering display mode.	24
EQUATIONS	■ EQUATIONS Displays the list of equations.	72
EVAL	EVAL Evaluates the current equation.	75
e^x	e^x Natural antilogarithm. Raises *e* to the power of the number in the display.	42
→°F	■ UNITS {TMP} {→°F} Converts degrees Celsius to degrees Fahrenheit.	53
FP	■ PARTS {FP} Fractional part of a number.	52
FX	■ DISP {FX} Selects FIX mode; allows you to specify the number of displayed decimal places.	23
→GAL	■ UNITS {VOL} {→GAL} Converts liters to gallons.	53
GR	■ MODES {GR} Sets Grads angular mode.	45

Function	Keys and Description	Page
→HMS	■ H↔HMS {→HMS} Converts decimal hours (degrees) to H.MMSS (D.MMSS) format.	46
H↔HMS	■ H↔HMS Displays menu for decimal hours/hours-minutes-seconds conversions.	46
→HR	■ H↔HMS {→HR} Converts H.MMSS (D.MMSS) format to decimal hours.	46
HX	■ BASE {HX} Sets hexadecimal (base 16) mode.	54
→IN	■ UNITS {L} {→IN} Converts centimeters to inches.	53
INPUT	INPUT Separates numbers in two-argument functions; enters equations; enters values into variables during EVAL and SOLVE.	21
IP	■ PARTS {IP} Integer part of number.	52
→KG	■ UNITS {M} {→KG} Converts pounds to kilograms.	53
LAST	■ LAST Displays previous result.	36
→LB	■ UNITS {M} {→LB} Converts kilograms to pounds.	53
LIBRARY	■ LIBRARY Displays the equation library.	91
→LTR	■ UNITS {VOL} {→LTR} Converts gallons to liters.	53
LN	LN Natural logarithm.	42
LOG	■ LOG Common (base 10) logarithm.	42
m	STAT {L.R.} {m} Slope of the line computed by linear regression.	63

Function	Keys and Description	Page
MEM	■ MEM Displays available memory, accesses variables catalog.	27
MODES	■ MODES Displays menu for changing angular and decimal-point modes.	18
n	STAT {Σ} {n} Number of x- or x,y-items accumulated in the statistical registers.	62
n!	■ PROB {n!} Factorial.	51
OC	■ BASE {OC} Sets octal (base 8) mode.	54
OFF	■ OFF Turns the calculator off.	12
PARTS	■ PARTS Displays menu for calculating parts of numbers.	52
Pn,r	■ PROB {Pn,r} Permutations of n items taken r at a time.	50
PROB	■ PROB Displays menu for probability functions.	50
r	STAT {L.R.} {r} Correlation coefficient of the x,y statistical data.	63
→RAD	■ D↔RAD {→RAD} Converts angle in decimal degrees to radians.	46
RADIUS	■ RADIUS Coordinate conversions; stores or calculates the r polar coordinate.	48
RCL	RCL Recalls variables A through Z or contents of polar/rectangular conversion registers.	37
RD	■ MODES {RD} Sets Radians angular mode.	45
RN	■ PARTS {RN} Rounds the displayed number to the number of decimal places specified by the current display format.	52

Function	Keys and Description	Page
SC	■ [DISP] {SC} Sets scientific display mode.	23
SHOW	■ [SHOW] Temporarily shows all 12 digits of number.	26
SIN	[SIN] Sine.	45
SINH	■ [HYP] [SIN] Hyperbolic sine.	51
SOLVE	■ [SOLVE] Solves the current equation for any variable.	77
STAT	[STAT] Displays menu for accessing statistical functions.	62
STO	[STO] *variable* Stores the displayed number into the designated variable or polar/rectangular conversion register.	37
STO +	[STO] [+] *variable* Stores *variable* + displayed number into *variable*.	39
STO −	[STO] [−] *variable* Stores *variable* − displayed number into *variable*.	39
STO ×	[STO] [×] *variable* Stores *variable* × displayed number into *variable*.	39
STO ÷	[STO] [÷] *variable* Stores *variable* ÷ displayed number into *variable*.	39
SWAP	■ [SWAP] Interchanges numbers separated by an operator or colon.	36
sx	[STAT] {S} {SX} Standard deviation of the *x* statistical data.	63
sy	[STAT] {S} {SY} Standard deviation of the *y* statistical data.	63
TAN	[TAN] Tangent.	45
TANH	■ [HYP] [TAN] Hyperbolic tangent.	51

Function	Keys and Description	Page
VARS catalog	■ [MEM] {VARS} Displays catalog of variables.	40
x^2	■ [x^2] Square.	42
$\sqrt{x}$	[$\sqrt{x}$] Square root.	42
$\bar{x}$	[STAT] {$\bar{x}$,$\bar{y}$} {$\bar{x}$} Mean of the *x* statistical data.	63
$\hat{x}$	[STAT] {L.R.} {$\hat{x}$} Calculates an estimate of *x* for the displayed *y* using linear regression and the *x*,*y*-statistical data.	63
xCOORD	■ [xCOORD] Coordinate conversions; stores or calculates the *x*-coordinate.	48
$\bar{x}$w	[STAT] {$\bar{x}$,$\bar{y}$} {$\bar{x}$w} Weighted mean of the *x* statistical data weighted according to the *y*-values.	63
$\bar{y}$	[STAT] {$\bar{x}$,$\bar{y}$} {$\bar{y}$} Mean of the *y* statistical data.	63
$\hat{y}$	[STAT] {L.R.} {$\hat{y}$} Calculates an estimate of *y* for the displayed *x* using linear regression and the *x*,*y*-statistical data.	63
yCOORD	■ [yCOORD] Coordinate conversions; stores or calculates the *x*-coordinate.	48
y^x	[y^x] Exponentiation operator.	32

Index

Page numbers in **bold** type indicate primary references; page numbers in regular type indicate secondary references.

Special Characters

A

B

E

F

L

M

N

O

P

Q

R

T

U

V

W

X

Y

Contacting Hewlett-Packard

For Information About Using the Calculator. If you have questions about how to use the calculator, first check the Table of Contents, the Subject Index, and "Answers to Common Questions" in appendix A. If you can't find an answer in the manual, you can contact the Calculator Support Department:

Hewlett-Packard
Calculator Support
1000 N.E. Circle Blvd.
Corvallis, OR 97330, U.S.A.

(503) 757-2004
8:00 a.m. to 3:00 p.m. Pacific time
Monday through Friday

For Service. If your calculator doesn't seem to work properly, see appendix A to determine if the calculator requires service. Appendix A also contains important information about obtaining service. If your calculator does require service, mail it to the Calculator Service Center:

Hewlett-Packard
Calculator Service Center
1030 N.E. Circle Blvd.
Corvallis, OR 97330, U.S.A.

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