HEWLETT® PACKARD

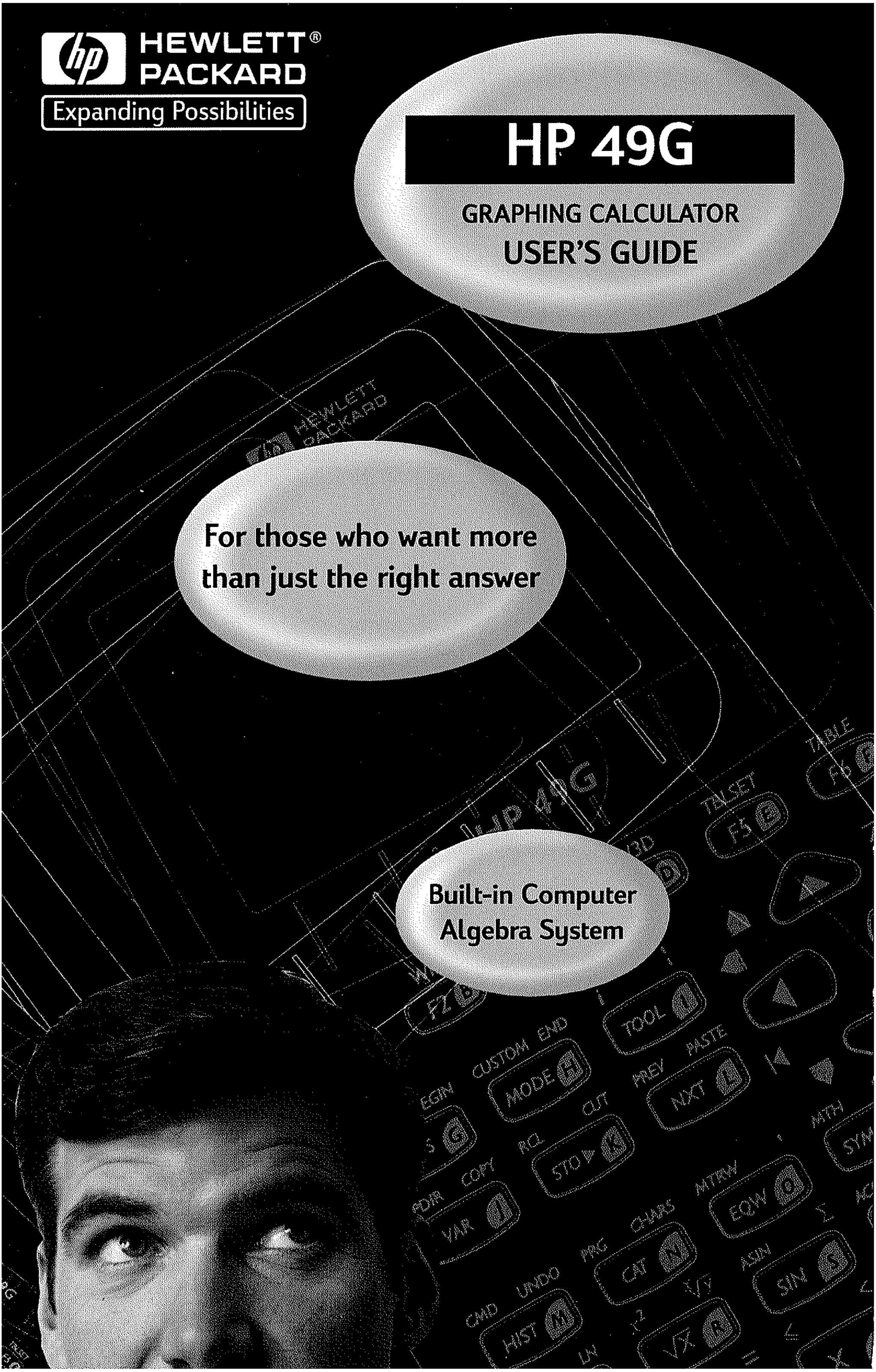
Expanding Possibilities

# HP 49G

## GRAPHING CALCULATOR USER'S GUIDE

For those who want more than just the right answer

Built-in Computer Algebra System

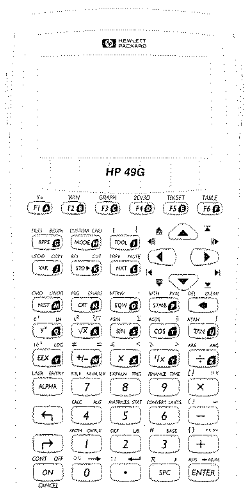


# HP 49G

## GRAPHING CALCULATOR

# USER'S GUIDE

Version 1.2




HEWLETT® PACKARD

Expanding Possibilities

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# Preface

## Contents



## The purpose of this manual

This manual provides a wide-ranging introduction to the features and functions of the HP 49G graphing calculator. It is both a guide to getting started and a reference manual.

Topics cover:

- the features of the HP 49G
- how to use the HP 49G to perform a wide range of mathematical and statistical calculations (with an emphasis on the fundamental mathematics taught at high schools, colleges, and universities)
- how to plot graphs
- how to use the special programming language of the HP 49G to write and store programs
- care and maintenance.

# Advanced functions

This manual will meet the needs of the majority of users. However, the HP 49G has numerous advanced functions designed especially for professional mathematicians, engineers, and statisticians.

In line with Hewlett-Packard's environment policy—which, in part, aims to minimize the use of paper products—instructions on how to use the advanced functions of the HP 49G are not included in this manual, but are published, instead, on the World Wide Web.

# HP 49G on the World Wide Web

You can find much information about the HP 49G on the World Wide Web. This manual is available on the Web, as is *Advanced User's Guide*. *Advanced User's Guide* covers those functions that have been designed especially for professional mathematicians, engineers and statisticians. It also provides:

- tips and tricks that will benefit all users
- a guide to getting the most out of the HP 49G's computer algebra system
- advanced plotting and programming techniques
- reference lists (such as a list of the HP 49G's commands).

You can access this user's guide and *Advanced User's Guide* by visiting www.hp.com/calculators/hp49.

# Regulatory information

This section contains information that shows how the HP 49G graphing calculator complies with regulations in certain regions. Any modifications to the calculator not expressly approved by Hewlett-Packard could void the authority to operate the HP 49G in these regions.

## USA

This calculator generates, uses, and can radiate radio frequency energy and may interfere with radio and television reception. The calculator complies with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation.

However, there is no guarantee that interference will not occur in a particular installation. In the unlikely event that there is interference to radio or television reception (which can be determined by turning the calculator off and on), the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Relocate the calculator, with respect to the receiver.

### Connections to Peripheral Devices

To maintain compliance with FCC Rules and Regulations, use only the cable accessories provided.

## Canada

This Class B digital apparatus complies with Canadian EMC Class B requirements.

Cet appareil numérique de la classe B est comforme à la classe B des normes canadiennes de compatibilité électromagnétiques (CEM).

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HP 49G Graphical Calculator
Warranty period: 12 months

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# Chapter 1

# Keys

## Contents



## Introduction

This chapter:

- illustrates the HP 49G keyboard
- describes the seven HP 49G keyboards
- briefly describes the purpose of each key.

# Key map

The following is an illustration of the layout of the keys on the HP 49G. The keys are described in "What each key does" on page 1-5, where each key—with the exception of the arrow keys—is grouped according to the row in which it appears. The arrow keys are explained at the end of the chapter.

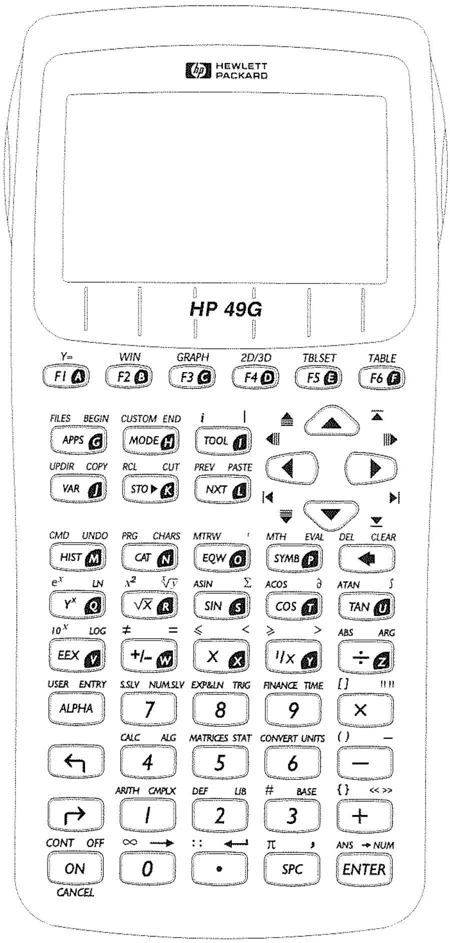



Figure 1.1: HP 49G key map

# The HP 49G's keyboards

The HP 49G keyboard is seven keyboards in one. These are:

- **Primary keyboard**: comprises all the keys from the second row to the last row of the keypad (from APPS to ENTER) when pressed on their own. The function of the keys on the primary keyboard is indicated by the main label or symbol on the face of the key. For example, MODE indicates that the key, when pressed on its own, is used to view and change the calculator's modes.
- **Function keyboard**: comprises the six keys on the first row of the keypad—labelled F1 to F6—when pressed on their own. Unlike the keys of the primary keyboard, the function of a key on the function keyboard is dependent on the context. For example, in some contexts F1 enables you to edit an object; in other contexts, F1 enables you to select a variable, submenu, or directory.
- **Left-shift keyboard**: comprises keys pressed in combination with the ⬑ key. The ⬑ key is pressed first followed by another key. The function performed by a particular left-shift key combination is indicated by the blue label above a key. For example, the label "FILES" appears in blue above the APPS key. This indicates that File Manager can be opened by pressing ⬑ and then the APPS key.

  Note that in RPN mode, key combinations involving ⬑ and a function key require you to keep ⬑ pressed while pressing the function key.

  In this guide, an instruction to use the left-shift keyboard is indicated by the left-shift symbol—⬑—followed by the *label* that indicates the function to be selected (such as FILES). Note that the label is *not* a key. (To continue the example, there is no FILES key. To invoke the Files function—that is, open File Manager—you press ⬑ and the key beneath the FILES label: APPS.)
- **Right-shift keyboard**: comprises keys pressed in combination with the ⬏ key. The ⬏ key is pressed first followed by another key. The function performed by a particular right-shift key combination is indicated by the red label above a key. For example, the label "PASTE" appears in red above the NXT key. This indicates that you can invoke the Paste function by pressing ⬏ and the NXT key.

  In this guide, an instruction to use the right-shift keyboard is indicated by the right-shift symbol—⬏—followed by the *label* that indicates the function to be selected (such as PASTE). Note that the label is *not* a key. (To continue the example, there is no PASTE key. To invoke the Paste function, you press ⬏ and the key beneath the PASTE label: NXT.)

Keys

- **Alpha keyboard**: comprises the keys with the characters A to Z marked on their face. (These characters are colored white on a green background.) You need to activate the alpha keyboard before you can enter an alphabetic character. (Until you activate the alpha keyboard, these keys belong to the primary or function keyboard, as described above).

  You activate the alpha keyboard by pressing ALPHA. For example, to enter *T* press ALPHA—thereby activating the alpha keyboard—and COS (since COS is the primary key that has *T* marked on it).

  You can keep the alpha keyboard active by pressing ALPHA twice. Every character you subsequently enter is a character from the alpha keyboard. In this situation, you press ALPHA again to deactivate the alpha keyboard.

  While the alpha keyboard is active, you can press the keys on the numeric keypad if you want to add a number to a text string.

  The alpha keyboard is described in more detail in chapter 2, "Basic operation".

- **Alpha left-shift keyboard**: comprises the keys of the alpha keyboard (see above) when pressed in combination with the ⬑ key. The ALPHA key is pressed first—to activate the alpha keyboard—followed by the ⬑ key (which activates the alpha left-shift keyboard). Finally, some other key is pressed to enter a character.

  The characters you can enter using the alpha left-shift keyboard are lower-case alphabetic characters and various symbols. These are shown in blue above the keys in the illustration on the front cover of the pocket guide.

  For example, to enter a lower-case *t*, press ALPHA ⬑ COS.

- **Alpha right-shift keyboard**: comprises the keys of the alpha keyboard (see above) when pressed in combination with the ⬏ key. The ALPHA key is pressed first—to activate the alpha keyboard—followed by the ⬏ key (which activates the alpha right-shift keyboard). Finally, some other key is pressed to enter a character.

  The characters you can enter using the alpha right-shift keyboard are characters of the Greek alphabet, arrows, and various symbols. These are shown in red above the keys in the illustration on the front cover of the pocket guide.

  For example, to enter σ, press ALPHA ⬏ SIN.

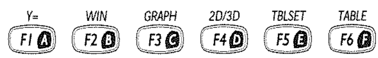
In addition to the seven keyboards discussed above, you can also create a customized keyboard. A customized keyboard—also known as the *user keyboard*—is one where alternative functionality is assigned to one or more keys. This is discussed in detail in *Advanced User's Guide*, found at http://www.hp.com/calculators/hp49.

# What each key does

This section describes the function of each key and main key combinations. Note that the keys and key combinations are listed in the order that they appear on the keyboard (see keyboard map on page 1-2).

The syntax required for various functions is also given. This syntax assumes that you are working in algebraic mode, not RPN mode. (These modes are explained in chapter 2, "Basic operation".)

## Row 1




(Y=) List equations to plot or open Matrix Writer if you have chosen to plot statistical data.

(WIN) Specify plot window parameters.

(GRAPH) Draw specified plots.

(2D/3D) Specify plotting parameters.

(TBLSET) Customize a table of plotted points.

(TABLE) Draw a table of plotted points.

(F1) – (F6) Keys of the function keyboard (see previous section). The function of these keys varies according to context.

## Row 2


(FILES) Open File Manager.

(BEGIN) Mark the start of something you want to copy or cut.

(CUSTOM) Display your custom menu.

(END) Mark the end of something you want to copy or cut.

(*i*) Enter the symbolic constant *i*, the square root of –1.

(|) Enter a *where* function.

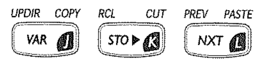
(APPS) View a list of all the calculator's applications.

(MODE) View and change the calculator's modes and flags.

(TOOL) Display a menu of commands relevant to the current application.

*The arrow keys are discussed at the end of this chapter.*

## Row 3




(UPDIR) Select the next directory up the directory tree.

(COPY) Copy a selection.

(RCL) Recall the value of a specified variable.

(CUT) Cut a selection.

(PREV) Display the previous page of a multi-page function-key menu.

(PASTE) Paste a selection that you have copied or cut.

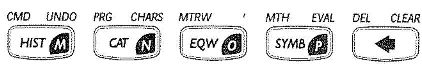
(VAR) Display the variables contained in the current directory.

(STO▶) Store the current object in a variable.

(NXT) Display the next page of a multi-page function-key menu.

*The arrow keys are discussed at the end of this chapter.*

## Row 4




(CMD) Display a list of the last four commands or calculations.

(UNDO) Restore history to what it was before the last operation.

(PRG) Display the programming menu.

(CHARS) Display all the characters that can be entered.

(MTRW) Open Matrix Writer.

(') Enter tick marks, to delimit an algebraic object.

(MTH) Display the mathematics menu.

(EVAL) Evaluate an expression.

(DEL) Delete the last object in history (or, in RPN mode, the entire stack).

(CLEAR) Clear history.

(HIST) Display, and access, all previous calculations and results.

(CAT) Display a list of all the calculator's commands, including those that have been added in libraries.

(EQW) Open Equation Writer.

(SYMB) Display a menu of sub-menus, each listing the more commonly used symbolic commands.

(◀) Delete the character to the left of the cursor.

Keys

## Row 5


$e^x$ — Calculate the natural antilog of a specified number. Syntax: $e^x$ $x$

LN — Calculate the natural logarithm of a specified number. Syntax: LN $x$

$x^2$ — Calculate the square of a specified number. Syntax: $x^2$ $x$

$\sqrt[x]{y}$ — Calculate the $x$th root of $y$. Syntax: $\sqrt[x]{y}$ $(x, y)$

ASIN — Calculate the arc sine of an angle. Syntax: ASIN $x$

Σ — Perform summation of numbers within specified limits. Syntax: $\Sigma(r=i, j, S)$ where $r$ is the summation index, $i$ is the initial value, $j$ is the final value and $S$ is the summand.

ACOS — Calculate the arc cosine of an angle. Syntax: ACOS $x$

∂ — Enter the differentiation sign.

ATAN — Calculate the arc tangent of an angle. Syntax: ATAN $x$

∫ — Enter the integration operator.

$y^x$ — Calculate $y$ to the power of $x$. Syntax: $y$ $y^x$ $x$

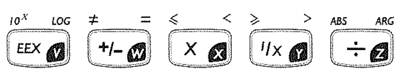
$\sqrt{x}$ — Calculate the square root of $x$. Syntax: $\sqrt{x}$ $x$

SIN — Calculate the sine of an angle. Syntax: SIN $x$

COS — Calculate the cosine of an angle. Syntax: COS $x$

TAN — Calculate the tangent of an angle. Syntax: TAN $x$

## Row 6




$10^x$ — Calculate the common (base 10) antilogarithm of a number. Syntax: $10^x$ $x$

log — Calculate the common (base 10) logarithm of a number. Syntax: log $x$

≠ — Insert a not-equals sign.

= — Insert an equals sign.

≤ — Insert a less-than-or-equal-to sign.

< — Insert a less-than sign.

≥ — Insert a greater-than-or-equal-to sign.

> — Insert a greater-than sign.

ABS — Display the absolute value of a real or complex number. Syntax: ABS $x$

| | |
|---|---|
| ARG | Calculate the angle defined by a complex number. Syntax: ARG $a + bi$ |
| EEX | Insert the exponent symbol and treat the entry in mantissa-and-exponent format. |
| +/- | Change the sign of a number. |
| $x$ | Insert an $x$. |
| $1/x$ | Calculate the inverse of a number. Syntax: $1/x$ $x$ |
| ÷ | Perform division. Syntax: $x$ ÷ $y$ |

## Row 7


| | |
|---|---|
| USER | Activate the user keyboard. |
| ENTRY | Change entry mode. |
| S.SLV | Display a list of commands used to solve equations symbolically. |
| NUM.SLV | Display a menu of applications used to solve equations numerically. |
| EXP&LN | Display a list of exponential and logarithm functions. |
| TRIG | Display a list of trigonometry functions. |
| FINANCE | Display an input form for performing financial calculations. |
| TIME | Open the time application to set the time and alarms. |
| [ ] | Enter square brackets, for delimiting a vector or array. |
| " " | Enter quote marks, for delimiting a string. |
| ALPHA | Activate the alpha keyboard. |
| 7 – 9 | Enter numbers. |
| × | Perform multiplication. Syntax: $x$ × $y$ |

## Row 8

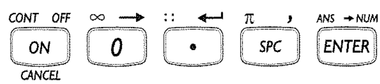

| | |
|---|---|
| CALC | Display a list of calculus functions. |
| ALG | Display a list of algebra functions. |
| MATRICES | Display a list of matrix functions. |
| STAT | Display a list of statistics applications. |
| CONVERT | Display a list of conversion functions. |
| UNITS | Open the units application. |
| ( ) | Enter parentheses, for enclosing parameters. |
| _ | Enter underscore, to create a unit object. |
| ← (left-shift) | Select the left-shift keyboard or alpha left-shift keyboard. |

| | |
|---|---|
| 4 – 6 | Enter numbers. |
| − | Perform subtraction. Syntax: $x$ − $y$ |

## Row 9

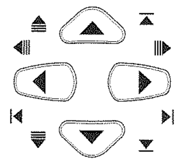

| | |
|---|---|
| ARITH | Display a list of arithmetic functions. |
| CMPLX | Display a list of functions relating to complex numbers. |
| DEF | Store an expression or define a user function. |
| LIB | List all libraries. |
| # | Enter a # symbol (to, for example, enter a binary integer) |
| BASE | Display a list of functions relating to binary arithmetic. |
| { } | Enter braces, for delimiting a list. |
| << >> | Enter angle brackets, to delimit programming code. |
| ↱ | Select the right-shift or alpha right-shift keyboard. |
| 1 – 3 | Enter numbers. |
| + | Perform addition. Syntax: $x$ + $y$ |

## Row 10




| | |
|---|---|
| CONT | Continue a halted program or suspended application. |
| OFF | Turn off the calculator. |
| ∞ | Enter the infinity symbol. |
| → | Enter a right-pointing arrow. |
| : : | Tag an object. |
| ↵ | Start a new line. |
| π | Enter pi. |
| , | Enter a comma. |
| ANS | Recall a previous answer. |
| →NUM | Display the result in approximate mode. |
| ON | Turn the calculator on. |
| 0 | Enter a zero. |
| • | Enter a decimal point. |
| SPC | Enter a space. |
| ENTER | Obtain a result or select an option. |
| CANCEL | Cancels an operation. |

### Arrow keys



[⇞] Move up to the first object or field shown.

[▲] Move up to the previous object or field.

[⤒] Move up to the first object or field.

[◀|||] Move to leftmost object or field shown.

[|||▶] Move to rightmost object or field shown.

[◀] Move left to the previous object or field.

[▶] Move right to the next object or field.

[|◀] Move left to the first object or field.

[▶|] Move right to the last object or field.

[⇟] Move down to the last object or field shown.

[▼] Move down to the next object or field.

[⤓] Move down to the last object or field.

# Key conventions

In this guide, a key press is represented in one of three ways:

- A function key operation is indicated by small capitals. The text of the operation matches the text displayed on a function-key menu (that is, a menu displayed along the bottom of the screen).

  For example, an instruction to press EDIT is an instruction to press whatever function key is directly below the word EDIT displayed at the bottom of the screen. (Function keys are the keys marked [F1] to [F6].)
- An operation initiated by pressing a key or keys other than a single function key is indicated by one or more key characters. Some examples are [SIN], [↱][WIN], [▶], and [MODE].

  Note that where a key character appears on its own, press the corresponding key; for example, [EQW]. Where a key character is preceded by [↰] or [↱], the key character refers to a label printed above a key. After you press [↰] or [↱], press the key below the label. For example, an instruction to press [↰][ABS] is an instruction to press [↰] followed by [÷] since ABS is a label above the [÷] key.
- The key for a number or alphabetic character is indicated by the number or character: for example, 4, A.

# Chapter 2

# Basic operation

## Contents

# Introduction

This chapter explains how to quickly get started using your HP 49G. You will learn how to adjust the calculator's display and how to set various modes that determine how the calculator behaves.

Various ways of entering data are covered. You are also introduced—with the help of a number of examples—to entering calculations.

The HP 49G has a useful alarm function. You use this function to set yourself reminders and to run programs at set times.

# Turning on and turning off

## Turning on

To turn on the HP 49G, press ON.

When you first turn on the calculator, a "Try to Recover Memory?" message is displayed. You should respond by pressing NO.

If the calculator does not turn on when you press ON, the batteries may need replacing. See appendix D, "Troubleshooting", for instructions on replacing the batteries.

If the message "Invalid Card Data" is displayed each time you turn the calculator on, you need to initialize the calculator's ports. See page D-6 for instructions.

When you turn on the calculator, the screen redisplays the data that was displayed when you last turned the calculator off.

The HP 49G has an automatic power-saving switch. This switch is activated when there has been no calculator activity for 5 minutes. When this occurs, the screen will go blank. You can restore the display—and its contents—by pressing ON.

When the calculator is already on, pressing ON is equivalent to pressing CANCEL.

## Changing the screen contrast

To change the display contrast (thereby darkening or lightening the text relative to the background):

1. press and hold (ON)
2. press (+) to darken text or (−) to lighten text
3. release (ON) when the contrast is satisfactory.

## Turning off

To turn off the calculator, press (↱) (OFF).

You do not have to save your history before turning off the calculator. (History is explained on page 2-6.) When you next turn the calculator on, your history will be redisplayed.

# Default screen

The screen that appears when you turn on the calculator is called the default screen.

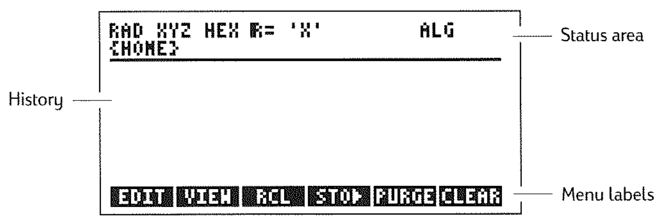



Figure 2-1: The default screen

Many of your calculator operations can be done from the default screen. However, when you open various applications—such as Equation Writer, Matrix Writer, and so on—the display will change to provide you with tools for working with that application.

There are three main components of the default screen:

- status area
- history
- menu.

In addition to the status history, and menu, the bottom line of the display becomes the command line when you start to enter data. The command line—or user input line—is discussed on page 2-7.

## Status area

The status area displays annunciators, the current directory path, and messages. It also displays various alerts.

Annunciators indicate the settings you have selected, certain keys you have pressed, and the status of the calculator. The full set of annunciators is given in table 2.1.

By default, the status area takes up two lines. You can reduce this to one line, or choose not to display the status area. You might do this to see more of your history area. See “Display modes” on page 2-19 for information on changing the size of the status area.

| Symbol | Meaning |
|---|---|
| ↰ | You have pressed [↰]. |
| ↱ | You have pressed [↱]. |
| α | The alpha keyboard is active: you have pressed [ALPHA]. |
| ((•)) | This indicates an alert. For example, an appointment has become due, or battery power is low. A message on the line below the annunciator explains the alert. |
| ⌛ | The calculator is busy. |
| ⊶ | Data is being transmitted to an external device. |
| DEG | The angle unit is set to degrees. |
| RAD | The angle unit is set to radians. |
| GRD | The angle unit is set to gradians. |
| XYZ | The coordinates notation is rectangular. |
| R∠Z | The coordinates notation is polar or cylindrical. |
| R∠∠ | The coordinates notation is polar or spherical. |
| HLT | A program has been halted or an application suspended. |
| 1US | The user keyboard is active for one operation. |
| USR | The user keyboard is active until you press [↰] [USER]. |
| ALG | Algebraic mode is active. |
| PRG | Program mode is active. |
| ~ | Results are displayed in approximate mode. |

| Symbol | Meaning (Continued) |
|---|---|
| ::: | Results are displayed in exact mode. |
| R | Real number mode. |
| C | Complex number mode. |
| X (or Y...) | The current independent variable. |
| DEC | Decimal base. |
| BIN | Binary base. |
| HEX | Hexadecimal base. |
| OCT | Octal base. |

Table 2-1: Annunciators

## History

All the objects you create with the HP 49G—equations, calculations, graphics, plots, programs, variables, and so on—are displayed in the history area of the screen. (See figure 2.1 on page 2-3.) Press (▲) or (▼) to scroll through the history. You can also select a previous object to use again or to incorporate into a new object on the command line.

To insert an object from history onto the command line, place the cursor where you want the object inserted and:

1. Press (HIST).
2. Press (▼) or (▲) until the object you want to select is highlighted.
3. Press (ENTER).

You can see more of your history by reducing the size of the status area or reducing the system font size. (See "Display modes" on page 2-19.)

Your objects remain in history until you delete them. They are automatically saved when you turn off the calculator. You can clear your history by pressing (↱) (CLEAR).

# Menu

A menu is displayed across the bottom of most screens. Each item on the menu is one of the following:

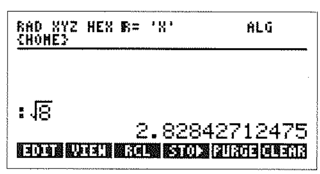
- a command
- the name of another menu
- a variable
- a subdirectory.

The menu changes according to the key, command, or sub-menu you select. For example, if you press (VAR), the menu displays the variables and directories you can access from your current path. (Variables are the named objects that you have created and saved, and subdirectories are areas of memory you have set aside and named, usually to help you better manage the storage of saved objects. Variables and directories are explained in detail in chapter 7, "Storing objects".)

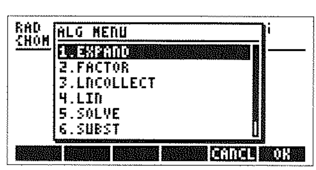
When you press certain other keys, the menu changes to show commands or other menus. When chosen, a command enables you to perform some operation on data, such as a mathematical operation, a storage operation, a unit conversion operation, and so on).

Many of the more commonly used commands have a key of their own. For example, you can store an object by pressing (STO▶), or find the sine of an angle by pressing (SIN). Other commands need to be selected from menus.

## Selecting a menu item




A menu item that is displayed at the bottom of the screen can be selected by pressing the function key—that is, one of the keys labelled (F1) to (F6)—directly below the item. In the example on the right, to select EDIT from the menu, you would press (F1), since (F1) is directly below EDIT.




While function key menus are widely available, most HP 49G commands are more easily accessible from choose list menus. This type of menu—in the form of a scrolling list—displays similar groups of commands (such as calculus commands, trigonometry commands, and so on). To see an example of such a menu, press (↱)(ALG).

Most menus can be displayed as a function key menu *and* as a choose list menu. Where this is the case, the default is to display the menu as a choose list. If you prefer all menus to be displayed as function key menus, clear flag –117.

### Multi-screen menus

There may be more function-key menu items than can be displayed on the one screen. In this case, press NXT—or ← PREV—to display further pages of the menu.

Where there are more items on a choose list menu than can be displayed on the one screen, press ▼ or ▲ to display further items. You can also jump directly to a choose list menu item by entering the first character of the item (or, in the case of numbered menus, the number of the item).

## Using the command line

The command line is the area of the display where you can enter and edit objects. It is always at the bottom of the display, immediately above the menu. (See figure 2.1 on page 2-3.)

You do not have to first select the command line before entering a new object. As soon as you start entering text—numbers or characters—the command line becomes active. For example, to multiply 5 by 6, enter 5 and note that the digit appears on the bottom line of your display. This is the command line. A flashing arrow to the right of the 5 indicates that you are in data entry mode. You then enter the rest of the object (by pressing X and 6 in the example).

When you have finished entering your object, press ENTER. If you entered a calculation, the result of your calculation is displayed on the screen, on the line below the calculation. Your calculation is retained so that you can see how you derived the answer. (See page 2-21 for an example.)

You cancel a command line entry by pressing CANCEL. You will be asked to confirm your intention if your entry exceeds the width of the screen.

## Multi-line entries

The information you enter on the command line can occupy more than one line, for example, when you are entering a program. (See chapter 10, "Introduction to programming", for information on entering programs.) To create a new line, press [→] [←]. What you have already typed moves up and a new line becomes available for you to continue entering your object.

You can set a display mode so that each new line is automatically indented. See "Display modes" on page 2-19 for information.

## Entering numbers

### Positive numbers

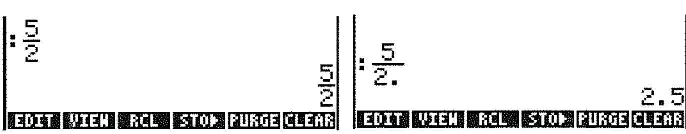
You enter a positive number by pressing the appropriate digit keys and, if necessary, the decimal point key ([•]).

### Negative numbers

To enter a negative number, type the number as if it was a positive number and then press [+/-]. The [+/-] key changes the sign of the number on the command line: from positive to negative, or negative to positive.

### Integers and real numbers

If you are working in exact mode—explained on page 2-23—the answer given to a calculation will depend on the way you represent integers. If you represent an integer as a real number—by entering a decimal point after the number—the HP 49G assumes that you want to switch to approximate mode (see page 2-23). Therefore, you can obtain an approximate answer in exact mode by entering integers as real numbers.




(A) (B)

Figure 2-2: In case (A) 2 is entered as an integer; in case (B), 2 is entered as a real number.

## Mantissa-and-exponent entry

1. Enter the mantissa (and, if necessary, press (+/-) to change its sign).
2. Press (EEX). An "E" is displayed to indicate that the exponent follows.
3. Enter the exponent (and, if necessary, press (+/-) to change its sign).
4. Press (ENTER).

A number entered as a mantissa and exponent will only be displayed as a mantissa and exponent if the number display mode is set to scientific or engineering. See the next section for information on number display modes.

Basic operation

## Number displays

Real numbers can be displayed in one of four modes:

- **Standard mode** displays numbers using full precision. All significant digits to the right of the decimal point are shown, to a maximum of 12 digits.
- **Fix mode** displays numbers rounded to a user-specified number of decimal places. A separator (comma or period) separates groups of three digits in real numbers greater than 999.
- **Scientific mode** displays a number as a mantissa—with one digit to the left of the decimal point and a user-specified number of decimal places—and an exponent. For example, 1234 appears as 1.23400E3 in scientific mode with 5 decimal places.
- **Engineering mode** displays a number as a mantissa with a user-specified number of decimal places, followed by an exponent that is a multiple of 3. For example, 87654 appears as 87.6540E3 in engineering mode with 4 decimal places.

The number display defaults to standard mode. You can change the display by pressing (MODE). This is explained in detail on page 2-18.

For fix, scientific, and engineering modes, the maximum number of decimal places you can specify is 11.

Basic operation

## Entering characters

The HP 49G's alpha keyboard enables you to enter letters and other characters. The (ALPHA) key is used, in various ways, to activate the alpha keyboard.

When the alpha keyboard is active, many of the keys become character keys. These are the keys that have a white letter printed on a green background in the bottom right corner.

The alpha annunciator—$\alpha$—appears in the status area whenever the alpha keyboard is active.

### Entering a single upper-case character

To enter a single upper-case character, press (ALPHA) and then the appropriate character key. (The alpha keyboard is deactivated after you press a character key.)

### Entering several upper-case characters

There are two ways to enter several upper-case characters one after the other:

- press (ALPHA) twice, enter the characters, and press (ALPHA) again, or
- hold (ALPHA) down, enter the characters and release (ALPHA).

Pressing (ALPHA) twice locks the alpha keyboard, keeping it active until you deactivate it (by pressing (ALPHA) again, or by pressing (ENTER) or (CANCEL)).

### Entering a single lower-case character

To enter a single lower-case character, press (ALPHA) (↰) and the appropriate character key.

### Entering several lower-case characters

To enter several lower-case characters one after the other:

1. If it is not locked already, lock the alpha keyboard (by pressing [ALPHA] twice).
2. Press [↰] [ALPHA]. The lower-case keyboard is now locked. Every character key you press now returns the character in lower case.
3. Enter the characters.

If you need to enter an upper-case character while the lower-case keyboard is locked, press [↰] before pressing the character key.

#### Unlocking the lower-case keyboard

Unlock the lower-case keyboard by pressing [↰] [ALPHA]. The alpha keyboard remains active, therefore any characters you now enter will be upper-case characters.

Press [ALPHA] to unlock the alpha keyboard and [ENTER] when you have finished your entry.

You can also unlock the lower-case keyboard—and the alpha keyboard—by pressing [ENTER] or [CANCEL].

## Entering special characters

### From the keyboard

When the alpha keyboard is locked, you can enter certain special characters by pressing keys in combination with [↱]. For example, letters of the Greek alphabet can be entered by pressing [↱] and a character key. Certain symbols—such as monetary units, arrows, @, and others—can also be entered by first pressing the [↱] key. These characters and symbols are shown above and to the right of the keys on the front cover of the HP 49G pocket guide.

When the alpha keyboard is locked, pressing [↰] and a character key produces a lower-case character (see above). If a numeric key is pressed instead, certain symbols are displayed. These characters and symbols are shown above and to the left of the keys on the front cover of the HP 49G pocket guide.

## Using the Characters tool

Most of the common characters you will need can be entered from the keyboard in the ways described earlier in this chapter. You can also enter these characters—and many more—using the Characters tool.

1. Press ⮣ CHARS to open the Characters tool.

   The Characters tool displays all 256 characters that can be displayed on the HP 49G.

2. If the character you want to select is not displayed, press ▼ until it is displayed.

   The ▼ key displays the next line of characters, or the first line of characters if you have reached the end of the characters display.

3. When the character you want to select is displayed, press the arrow keys until the character is highlighted.

4. If you want to copy just the highlighted character to the command line, press ECHO1. The Characters tool closes and the character you selected is copied to the command line.

5. If you want to copy the highlighted character and other characters, press ECHO. This copies the character you selected to the command line, and the Characters tool remains open so that you can select other characters. Repeat from step 2 to select other characters.

6. To close the Characters tool, press ENTER or CANCEL.

If the character highlighted in the Characters tool can be entered from the keyboard, the key or combination of keys required is displayed near the bottom left of the screen.

# Entering from history

You can also enter an item onto the command line from history.

1. Press HIST to display the history list.
2. Press ▲ or ▼ until the item you want to copy to the command line is highlighted.
3. Press ENTER.

## Editing the command line

Table 2.2 lists the command line operations available for moving through the command line, editing the text you have entered, and copying, moving and pasting text.

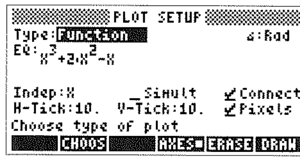
| Key(s) | Description |
|---|---|
| ◀ ▶ | Move the cursor left or right. |
| ↰ ◀\|\|\| ↰ \|\|\|▶ | Move the cursor to the first or last character shown on the screen. |
| ↱ \|◀ ↱ ▶\| | Move the cursor to the first or last character of the command line. |
| ▲ ▼ | If the command line has more than one line, move the cursor up or down a line. |
| ↰ ▲ ↰ ▼ | If the command line has more than one line, move the cursor to the first or last line shown on the screen. |
| ↱ ▲ ↱ ▼ | Move the cursor to the beginning or end of the command line. |
| ◀ | Delete the character to the left of the cursor. |
| ↰ DEL | Delete the character beneath the cursor. |
| ↱ BEGIN | Indicate the start of a selection of text that you want to copy or cut. |
| ↱ END | Indicate the end of a selection of text that you want to copy or cut. |
| ↱ COPY | Copy your selection. |
| ↱ CUT | Cut your selection. |
| ↱ PASTE | Paste, at the position of the cursor, the text you have copied or cut. |
| CANCEL | Discard the contents of the command line and return to the default screen. |
| TOOL F1<br>TOOL F2 | Skip to the start or end of the current word. |
| TOOL F3<br>TOOL F4 | Delete the characters to the start or end of the current word. If preceded by ↱, deletes all characters to the start of, or end of, the command line. |

Table 2-2: Command line editing tools

# Input forms

Many of the HP 49G's applications have input forms to help you remember the information you need to enter and to set various options.

An input form is just like a dialog box on a computer. The example on the right—displayed when you press ↰ 2D/3D—is the input form you use to set up a plot.




You need to highlight a field—by moving the cursor to it—before you can enter or change data in it. You move the cursor to a field by pressing the arrow keys.

## Input form fields

Each input form has a set of fields, a short help message relating to the currently highlighted field, and a menu that displays choices relevant to the currently highlighted field.

Four types of fields can appear on an input form: data fields, extended data fields, list fields, and check fields.

### Data fields

Data fields accept data of a particular kind directly from the keyboard. The Indep, H-Tick, and V-Tick fields in the above example are data fields. (These fields—and others on this input form—are explained in chapter 4, "Plotting graphs".)

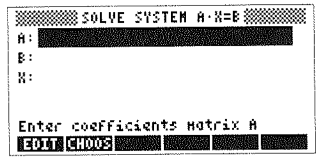
To enter or change the data in a data field:

1. Press an arrow key until the field is highlighted.
2. Press EDIT. Any data in the field is copied to the command line.
3. Enter or edit the data on the command line. (See "Using the command line" on page 2-7 for information.)

   Where the data is also the name of a variable, your entry will be evaluated and replaced with the variable's object. To use the name of a variable rather than the associated object, enclose the name in single quotes (that is, tick marks).
4. Press ENTER to copy the new data to the input form.

## Extended data fields

Extended data fields accept data entered directly from the keyboard or objects chosen from a list. The three fields in the example at the right are extended data fields.



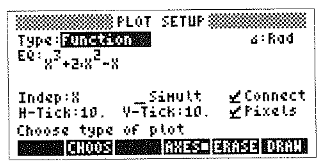

To enter data into an extended data field directly from the keyboard, follow the steps set out in the paragraphs on data fields above.

To choose a previously stored object:

1. Highlight the field and press CHOOS. A list of all suitable variables in the current directory is displayed.
2. Press ▲ or ▼ until the object you want to select is highlighted.
3. Press OK. The object you selected is copied to the input form.

## List fields

List fields accept only a limited, pre-determined set of values. The Type and ∡ fields in the example at the right are list fields.




To change the value in a list field:

1. Highlight the field and press CHOOS. A list of allowable values is displayed.
2. Use the arrow keys to highlight the value you want.
3. Press OK. The value you selected is copied to the form.

You can also select an item for a list field by:

- highlighting the field and pressing +/- until the option you want appears in the field or
- highlighting the field and pressing ALPHA followed by the first letter of the option you want (and repeating if necessary).

## Check fields

Check fields are used to turn an option on or off. The CONNECT, SIMULT, and PIXELS fields in the above example are check fields. A tick in a check field indicates that the option is selected; an empty field indicates that it is not selected.

To change the currently selected option in a check field, highlight the field and press CHK. If the field had a tick before, it is now blank (indicating that you have turned the option off). If it was blank before, it will now have a tick (indicating that you have turned the option on).

Some input form fields are both a data field and a list field. When such a field is highlighted, both the EDIT and CHOOS commands are available from the menu. You can either enter a new value for such a field, or select the value from a list.

## Resetting values to their defaults

To reset a value in an input form field to its default value:

1. Move the cursor to the field.
2. Press NXT.
3. Press RESET.
4. If you want to reset the values in *all* fields on the input form, press ▼ to select RESET ALL.

   The first option in the options list—RESET VALUE—restores just the value in the highlighted field to its default value. The second option—RESET ALL—restores all values on the form to their default values.
5. Press OK or ENTER.

## Input form help

In addition to the help message that prompts you for input, further help is provided by way of a list of valid object types for a field. To display this list for a particular field:

1. move the cursor to the field
2. press TYPES (found on the second page of the function key menu).

To hide the list of valid object types, press CANCEL.

### Using calculated values as input

With an input form displayed, you can perform a calculation and place the result of the calculation directly into a field.

1. Move the cursor to the field whose value you wish to calculate.
2. Press CALC.

   The CALC command is on the second page of the function key menu.
3. Perform the desired calculation.
4. If it is not already a real number, convert the result to a real number by pressing ⓡ →NUM.
5. Press OK to return to the input form. The result to the calculation will be in the field you highlighted at step 1.

## Closing an input form

An input form might be used to make global changes—for example, changing the date or time—or to set up the parameters for some other operation (such as setting the coordinates for plotting a particular equation).

If your input form will change global settings, press OK. This saves your settings and closes the form.

If your input form is designed to record the parameters for some further operation, a menu key is displayed representing that further operation. (For example, the input forms for plotting a graph will display a menu item labelled DRAW. Pressing the corresponding function key causes the equations specified to be drawn according to the parameters specified on the input forms. (See chapter 4, "Plotting graphs" for more information on plotting.)

To close an input form and discard the values you have entered, press CANCEL.

# Modes

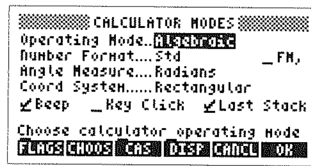
A mode is a way in which the HP 49G behaves. There are numerous modes. For example, one mode is the way that numbers are displayed (with a fixed number of decimal places, in scientific notation, and so on). Another mode controls the units in which angular measurements are interpreted: degrees, radians, or gradians.

## Changing a mode

Each mode has a default setting. To change a setting:

1. Press (MODE).

   The Calculator Modes input form is displayed. This input form enables you to change the settings of those modes that are most likely to need changing. It also gives you access to input forms for changing display modes and CAS modes.

   The modes that can be changed are discussed in the next three sections.

2. Change the setting of a mode.

   See “Input forms” on page 2-14 for information on changing the values in fields on input forms.

3. Press OK.

### Calculator Modes

The calculator modes are:

- **Operating mode:** controls how the HP 49G interprets and displays calculations. (See “Algebraic and RPN modes” on page 2-21.)
- **Number format**: controls how numbers are displayed and the number of decimal places displayed. (See “Number displays” on page 2-9.)
- **Angle measure:** controls the units in which angular measurements are interpreted: degrees, radians, or gradians.
- **Coordinate system:** controls how complex numbers and vectors are displayed. (See chapter 8 for more information.)
- **Beep:** a check field that enables you to turn on or turn off the system beep.

- **Key click:** a check field that enables you to turn on or turn off the beep that sounds when you press a key.
- **Fraction mark** (labelled "FM"): a check field that enables you to change the punctuation used to separate the integer from the fractional component of a real number. The default is a period. To use a comma, place a check mark in this field.
- **Last stack**: a check field that enables you to save memory by disabling the undo function. Note that the ANS command requires the Last stack field to be checked.



## Display modes

Display modes determine the size of the font in history, on the command line, and in Equation Writer. They also determine the font used, the number of status lines displayed (0,1, or 2), and whether and how the clock is displayed.

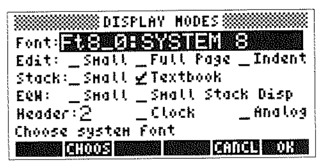
To change a display mode:

1. Press (MODE).

   The Calculator Modes input form is displayed.

2. Press DISP.

   The Display Modes input form is displayed.




3. Change the setting.
4. Press OK.

The display modes are:

- **Font:** enables you to choose a particular font as the standard system font.
- **Edit Small:** enables you to choose the minifont for command line entries. (The minifont is a small 6-pixel-by-4-pixel font.)
- **Full Page:** enables the cursor to be placed anywhere on the screen during editing rather than being restricted to the text being edited.
- **Indent:** switches on automatic line indenting in multi-line command line entries.
- **Stack: Small:** enables you to choose the minifont for the history and stack display.

- **Textbook:** enables you to display expressions and equations in single-line format (with /, ^, etc) instead of traditional textbook format (with stacked fractions, raised exponents, etc).
- **EQW Small:** enables you to choose the minifont for entries in Equation Writer.
- **EQW Small Stack Disp:** enables you to display equations and expressions in the minifont while other objects are displayed in the system font. This has effect only if you are in textbook mode.
- **Header:** determines the number of lines of information displayed in the header—that is, in the status area—of the screen. Valid values are 0, 1, and 2.
- **Clock:** enables you control whether the date and time are displayed.
- **Analog:** enables you choose between a digital and analog format for the clock display.

## CAS modes

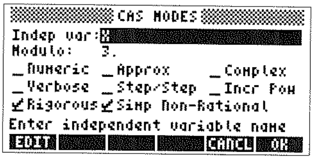
Certain modes relate to the HP 49G's computer algebra system (CAS). Some examples are the default independent variable, modulo variable, and complex number display. CAS modes are discussed in detail in chapter 5.

To change a CAS mode:

1. Press MODE.

   The Calculator Modes input form is displayed.
2. Press CAS.

   The CAS Modes input form is displayed.
3. Change the setting.
4. Press OK.



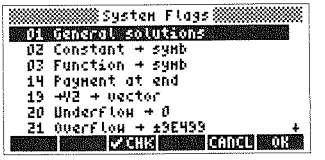

## Flags

The modes that you are more likely to want to change can be changed easily using the input forms described in the last three sections. There are, however, many more modes that you can change.

These additional modes can be changed by setting or clearing certain flags. For example, by setting flag –60, you can lock the alpha keyboard by pressing ALPHA once, rather than twice. Clearing flag –60 returns the mode to its default setting (where ALPHA must be pressed twice to lock the alpha keyboard).

You can display a list of flags by pressing FLAGS when the Calculator Modes input form is displayed. With the list displayed, you can set or clear particular flags.

To set or clear a flag:




1. Press ▼ or ▲ until the flag you want to change is highlighted.
2. Press CHK.

   If the flag was set before, it is cleared; if it was cleared before, it is now set. (The flag is set if it has a check mark beside it.)

# Algebraic and RPN modes

The HP 49G provides two modes for interpreting and displaying calculations: algebraic and RPN.

## Algebraic mode

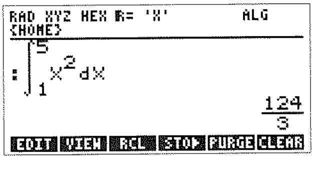
Algebraic mode is the default mode. In this mode, you perform calculations by entering the arguments *after* the command (which, in most cases, means entering numbers, functions, and operators in the same order that you would write down the expression on paper). For example, to find sin(30) in algebraic mode, you enter the command—SIN—and then the argument: 30.

You enter the command and its arguments on the command line and:

- press ENTER to obtain the result in exact mode, or
- press ↱ →NUM to obtain the result in approximate mode.

Exact mode and approximate modes are explained on page 2-22.

If a calculation yields a number of results, the results are displayed together in a list: {$\text{result}_1$, $\text{result}_2$, $\text{result}_3$, …}.




In algebraic mode, previous calculations are retained in history together with their results. Each calculation is displayed at the left of the screen, and the corresponding result is displayed on the next line at the right of the screen (as in the example on the right).

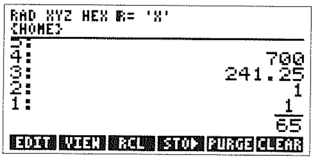
You can use the result of a previous calculation in a new calculation by entering ANS($n$) where $n$ is the number of the answer: 1 for the last answer, 2 for the second last, and so on. When you press (ENTER), the corresponding answer is copied to the cursor location on the command line.

## RPN mode

"RPN" stands for *reverse Polish notation*. In RPN mode, you typically enter an argument *before* the command. For example, to find sin(30) in RPN mode, you enter the argument —30—and then specify the command: (SIN).

In RPN mode, the results of previous calculations are listed as they are in algebraic mode. However, only the results—not the calculations—are listed.

This list of prior results—and other objects—is known as the *stack*, and each item on the stack is numbered (as in the example at the right).




If a calculation yields a number of results, each result is displayed as a separate item on the stack. (Some results may, however, be given as a list of results.)

The HP 49G has numerous commands for manipulating the objects on the stack. See appendix E, "Working in RPN mode".

For information on switching between algebraic and RPN display modes, see "Changing a mode" on page 2-18.

## Exact and approximate modes

The results of calculations can be displayed in exact mode or approximate mode. The default results mode—for both algebraic and RPN display modes—is exact.

See "Changing a mode" on page 2-18 for information on how to change modes. See chapter 5, "Working with expressions", for information on how this mode affects computer algebra functions.

## Exact mode

In exact mode, any result that is not a whole number is displayed in fractional or symbolic form. For example, 4 ÷ 2 will yield 2 (because 2 is a whole number), while 5 ÷ 2 will yield 5/2 (since 2.5 is not a whole number).

Similarly, sin(π/4) yields $\sqrt{2}/2$ rather than 0.707106781185.

Further examples are given in "Command line calculations" on page 2-24.

Note that you can force the calculator to yield an approximate answer while in exact mode by:

- entering at least one integer as a real number—that is, by following the integer with a decimal point—see "Integers and real numbers" on page 2-8, or
- pressing [↱] [→NUM] rather than [ENTER] to get the result.

## Approximate mode

In approximate mode, all numeric results are displayed in floating-point form where possible.

For example, sin(π/4) yields.707106781185 rather than $\sqrt{2}/2$.

Further examples are given in "Command line calculations" on the next page.

# Command line calculations

This section provides a number of examples of common types of calculations. The keystrokes needed—in algebraic mode—to enter the calculation on the command line, and the result in both exact and approximate mode, are listed. (The examples assume that the calculator is operating with its default mode settings.)

Chapters 5 and 6 explain how to use the commands and functions of the calculator's computer algebra system to set up and solve more-complex calculations. See chapter 5 for information on how to configure modes to get symbolic results to calculations.

**Example 1:** $(5 + 3) \times (6 - 3)$

Keys: (↰) (()) 5 (+) 3 (▶) (X) (↰) (()) 6 (−) 3 (ENTER)

Exact: 24

Approximate: 24.

**Example 2:** $\sqrt{45}/12$

Keys: (√x) 45 (÷) 12 (ENTER)

Exact: $\sqrt{5}/4$

Approximate: .559016994375

**Example 3:** $4^{-2}$

Keys: 4 ($y^x$) 2 (+/-) (ENTER)

Exact: 1/16

Approximate: .0625

Note that the (+/-) key changes the sign of the last number entered.

**Example 4:** $\sqrt[4]{2401}$

Keys: (↱) ($\sqrt[x]{y}$) 4 (↱) (,) 2401 (ENTER)

Exact: 7

Approximate: 7.

**Example 5:** $\int_1^5 x^2 dx$

Keys: [↱] [∫] 1 [↱] [,] 5 [↱] [,] [$x$] [$y^x$] 2 [↱] [,] [$x$] [ENTER]

Exact: 124/3

Approximate: 41.3333333333

**Example 6:** $\sqrt{\cos \frac{\pi}{3}}$

Keys: [$\sqrt{x}$] [COS] [↰] [$\pi$] [÷] 3 [ENTER]

Exact: $\sqrt{2}/2$

Approximate: .707106781185

# Time Management

By default, the HP 49G does not show the date and time. You can turn this function on by selecting CLOCK on the Display Modes input form (as explained on page 2-19). When the clock function is on, the date and time appear on the second line of the status area.

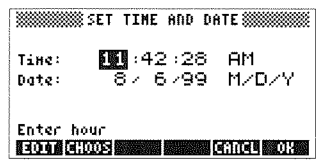
Even if you have chosen not to display the clock, you can use the appointments feature of the HP 49G to set reminders or to set programs to run at a specified time.

## Setting the date and time

To set the date or time:

1. Press ⟳ (TIME).
2. Press ▼ ▼ to highlight the SET TIME, DATE... function and then press OK.

   The Set Time and Date input form is displayed.




3. Press the appropriate arrow keys to highlight a value you want to set or change.
4. Change the value. (Each time and date field on this input form is both a data field and a list field. See "Input form fields" on page 2-14 for information on how to edit the fields on an input form.)
5. Repeat from step 3 if there are other values you want to change.
6. When all the values are correct, press OK.

The input form closes and the new date and time is displayed on the status line (providing that you have chosen to display the clock and the status area).

## Changing the format of the date or time

To change the format of the date or time:

1. Press ⮣ TIME.
2. Press ▼▼ to highlight the SET TIME, DATE... function and then press OK.

   The SET TIME AND DATE input form is displayed.
3. Press the appropriate arrow keys to highlight the format field you want to change.

   The format fields are the two fields at the far right of the screen.
4. Change the format. (The format fields are list fields. See "Input form fields" on page 2-14 for information on how to edit list fields on an input form.)
5. If you want to change another format, repeat from step 3.
6. When you have finished, press OK.
7. The input form closes and the date and time is displayed in the formats you set.

# Alarms

You can set two types of alarms: appointment alarms and control alarms.

### Appointment alarms

An appointment alarm is an alarm you set to go off at a particular time on a particular date. Typically, an appointment alarm is accompanied by a user-set message, for example, a reminder.

When the alarm falls due, a beep is emitted at short intervals for about 15 seconds. If you also specified a message when setting the alarm, that message is displayed in the status area, along with the alarm annunciator ((•)). The message is displayed only while the alarm is sounding.

You acknowledge an appointment alarm by pressing a key while the alarm is sounding. The beep stops, the annunciator disappears, and the message is deleted.

If you do not press a key while the alarm is sounding, the message disappears, but it is not deleted. (See "Checking, changing, and deleting alarms" on page 2-29 for information on following up alarms that you have missed.) If the alarm is a non-repeating alarm (explained in the next section) the annunciator remains displayed to indicate that you have an appointment you have not acknowledged.

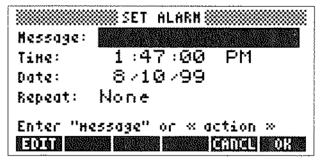
If the calculator is switched off, it automatically switches on when the alarm is due to go off. The alarm sounds, and the associated message is displayed.

Any number of appointment alarms can be set.

### Setting an appointment alarm

1. Press ↱ TIME.
2. Press ▼ to highlight the SET ALARM... function and then press OK.

   The SET ALARM input form is displayed.




3. If you want to set a message that will be displayed when the alarm goes off:
   a. Press ↱ " ".

      If you use any other delimiter, the HP 49G will consider the alarm to be a control alarm (see page page 2-29).
   b. Enter the message. (See "Entering characters" on page 2-10 for information on how to enter text.)
   c. Press OK.

   Only as much of your message as will fit on one line of the screen will be displayed, so you should keep your message brief.
4. If you have entered a message, the Hour field is now highlighted. If you did not enter a message, press ▼ until the Hour field is highlighted.
5. Change the time, time format and date to the time and date that you want the alarm to sound. (See "Input form fields" on page 2-14 for information on how to set the fields on an input form.)
6. If you want the alarm to repeat at regular intervals:
   a. Highlight the Repeat field.
   b. Type a value for the repeat interval.
   c. Press OK. The unlabeled Alarm Repeat Unit field is now highlighted.
   d. The Alarm Repeat Unit field is a list field. If the default alarm repeat unit is not what you want, select a new unit: seconds, minutes, hours, days, or weeks. (See "Input form fields" on page 2-14 for information on how to select values for a list field on an input form.)
7. Press OK to set the appointment alarm.

### Checking, changing, and deleting alarms

To look at the future-dated appointment alarms you have set, and the past-due non-repeating alarms that you did not acknowledge:

1. Press ⮣ TIME.

   The BROWSE ALARMS... option is highlighted.

2. Press OK.

   A list of past-due non-repeating alarms and future-dated alarms is displayed. The list shows the date and time the alarm was set to go off, whether it is a repeating alarm, and the first few characters of the message.

3. To read or change a listed alarm, press ▼ to highlight the alarm and then press EDIT. The SET ALARM input form is displayed. You can read the entire message and change the details of the alarm. See "Setting an appointment alarm" on page 2-28 for information on changing the data on the SET ALARM input form.

   To return to the list of alarms, press CANCEL or OK.

4. To delete an alarm, press ▼ to highlight the alarm and then press PURGE.

   If you do not delete a past-due alarm—that is, a non-repeating alarm that you did not acknowledge by pressing a key while the beep was sounding—the alarm annunciator will continue to be displayed in the status area.

5. To set a new alarm, press NEW and follow the instructions in "Setting an appointment alarm" on page 2-28, starting from step 3.

6. To return to your default display from the list of alarms, press OK.

## Control alarms

A control alarm runs a program or other object at the time and date you specify. You might set a control alarm to run a program at a time when you won't need the calculator if you know that the program will take some time to finish.

You do not need to acknowledge a control alarm. In fact, when a control alarm is set off, there is no beep and no annunciator.

You can view, change, and delete a control alarm in the same way that you view, change, and delete an appointment alarm. See "Checking, changing, and deleting alarms" on page 2-29.

### Setting a control alarm

1. Press ⓡ (TIME).
2. Press ▼ to highlight the SET ALARM... option and then press OK.
   The SET ALARM input form is displayed.
3. In the Message field, enter the name of the program or object that you want to run when the alarm becomes due.
4. Set the time and date to the time and date that you want the object to run.
5. If you want the object to run repeatedly at set intervals, enter a value in the Repeat field and select a unit for the Alarm Repeat Unit field.
6. Press OK to set the control alarm.

# Chapter 3

# Creating and editing expressions

## Contents





## Introduction

This chapter explains how to use Equation Writer to create and edit expressions. Expressions that you create are displayed as they are when you write them on paper. From the command line, you can open an expression in Equation Writer.

# Creating a new expression

This section describes how to use Equation Writer to create an expression, and to store it in a variable.

As you create an expression, you press ▶ to select the previous components that the new operator or function will relate to. Each time you press ▶, more of the previous components are selected.

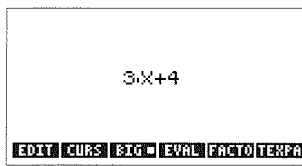
Consider the expression:

$$\frac{(3x+4)(5x^2-2)}{\sqrt[3]{x-1}}$$

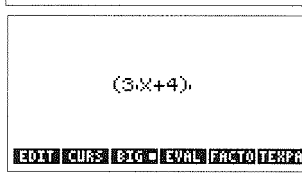
This is how you use Equation Writer to create the expression and save it in memory.



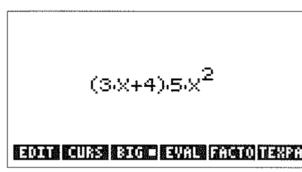
1. Ensure that the command line is clear, and press EQW to open Equation Writer.
2. Enter the first component.
   3 $x$ + 4



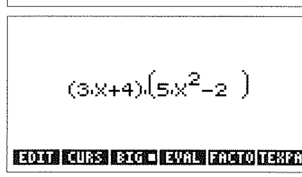

3. Select the component you entered, and then press ×. Equation Writer encloses the selected expression in brackets and inserts • to represent the multiplication.
   ▶ ×



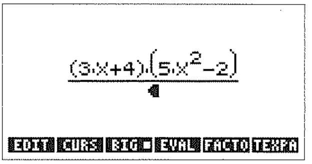

4. Enter the first term of the second component.
   5 $x$ $y^x$ 2



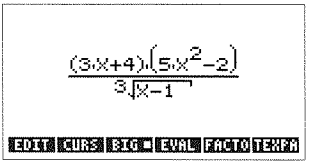

5. Select the term, and press − 2. Equation Writer creates the component, and encloses it in brackets.
   ▶ ▶ − 2



6. Select the expression you have entered so far, and press [÷] to insert the division bar under it.
   [▶][▶][▶][÷]




7. Enter the denominator expression.
   3[↱][ˣ√y][X][−]1




8. Press [ENTER] to place the expression on the command line.
9. To store the expression in memory:
   a. press [STO▶]
   b. press [ALPHA] [ALPHA] and then enter a name for the equation
   c. press [ENTER] to store the expression.

# Editing an expression

You can edit an expression on the command line, or in Equation Writer. See "Editing the command line" on page 2-13 for details on using the command line editor.

To edit an expression in Equation Writer:

1. With the expression on the command line, press [▼].
   Equation Writer opens with the expression ready for editing.
2. Edit the expression.
3. Press [ENTER] to place the expression on the command line.
4. Press [ENTER] again to save your changes.

If you want to insert a component into an expression, you can:

1. With the expression on the command line, place the cursor where you want the component to be inserted.
2. Press [EQW] to open Equation Writer with a blank screen.
3. Create the component.
4. Press [ENTER]. The component is inserted into the expression on the command line.
5. Press [ENTER] again to save the modified expression.

# Using Equation Writer

As you create or edit an expression, keep the following points in mind:

- You use the operators and the functions from the keyboard to specify the operations that your expression contains. For example, to include an arithmetic addition, press (+). To include a sine function, press (SIN).
- By default, any operation you select is applied to the function or term immediately to the left of the cursor. You press (▶) to extend the selection on the left to which the next operation will apply.

## Implied multiplication

You normally press (X) to specify multiplication. However, for certain expressions, Equation Writer assumes that multiplication is intended and you do not need to specify it. This is the case in the following situations:

- a number followed by a letter, for example $2x$
- a number or letter followed by an opening parenthesis
- a number or letter followed by a prefix function, that is a function where the arguments appear after the name, for example sin($x$).
- a right parenthesis followed by a left parenthesis.

## Entering *e* and *i*

To enter the value $e$, the base for natural logarithms, or $i$, the square root of –1, you can simply use the alpha keys to enter lower-case $e$ or $i$. That is:

- to enter $e$, press (ALPHA)(⬑)e
- to enter $i$, press (ALPHA)(⬑)i.

In algebraic expressions, the HP 49G recognizes these letters as the equivalent values.

You can also enter $i$ by pressing (⬑)($i$).

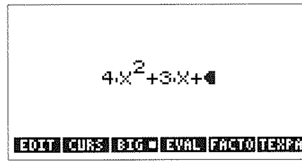
Creating and editing expressions

# Operating modes

There are four modes of operation within Equation Writer. These are:

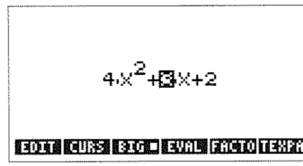
- Entry mode

  This is the default mode. If you are using another mode, Equation Writer returns to Entry mode whenever you enter a value.



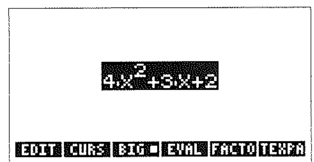

- Term selection mode

  Use this mode when you want to modify existing terms. You can select only one term at a time.



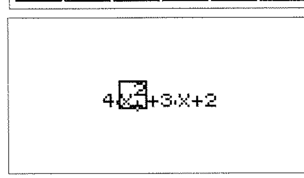

- Selection mode

  You use this mode when applying algebraic operations to components of an expression.




- Cursor mode

  You use this mode to select components of an expression.




## Working with modes

Equation Writer's functionality varies depending on the mode that you are using.

### Using Entry mode

1. Enter a term or operator to apply to the term immediately to the left of the cursor.
2. Press ▶ to select terms to the left of the cursor to which you want to apply the next operator or function. Each time you press ▶, more terms to the left are selected.

## Using Term selection mode:

1. To start Term selection mode:
   - From Entry mode, press ▼.
   - From Selection mode, press ↱▼.

   The cursor changes to a box.
2. Press ▶ and ◀ to navigate through the expression and select the term you want to change.
3. When the term that you want is selected, perform either of the following:
   - Enter a new term or terms to replace the selection.
   - Select a function or operator to apply to the selection.

   When you enter a term, function, or operator, Equation Writer returns to Entry mode.

## Using Selection mode

1. Press ▲ to start Selection mode.
2. Use the arrow keys to select the components that you want. See "How Equation Writer sees expressions" on page 3-7 to help understand how to select components.
3. When the part of the expression that you want is selected, perform one of the following:
   - Enter a new term or terms to replace the selection.
   - Select a function or operator to apply to the selection.
   - Use the computer algebra functions to manipulate the selection.
4. To return to Entry mode, enter a term, function, or operator. To return to Term Selection mode, press ↱▼.

## Using Cursor mode

Use Cursor mode to select parts of an expression. You cannot edit a selection in cursor mode.

1. Press CURS to start Cursor mode.
2. Use the arrow keys to enclose the selection you want in a box.
3. Press ENTER to select the boxed area, and return to Selection mode, or press CANCEL to return to Edit mode without selecting the boxed area.

## How Equation Writer sees expressions

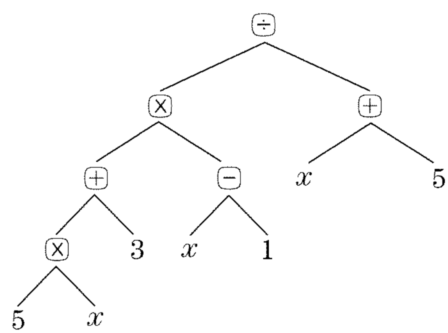
Understanding how Equation Writer sees expressions will help you work with expressions.

The expression that you are editing is represented within Equation Writer as a tree structure, with the operators as branching points, and operands as branches. You use the arrow keys to navigate around the tree and select groups of branches.

For example, consider the expression:

$$\frac{(5x+3)(x-1)}{(x+5)}$$

The tree structure for this expression appears as follows to Equation Writer:






In Selection mode, when the cursor is positioned on 5 in the $(5x + 3)$ component:

- If you press ▲ once, the selection point moves to the × operator and Equation Writer selects the $5x$ expression.
- If you press ▲ again, the selection point moves to the + operator, and Equation Writer selects the $(5x + 3)$ expression.
- If you press ▲ again, the selection point moves to the × operator, and Equation Writer selects the entire numerator.
- If you press ▲ again, the selection point moves to the top of the tree structure, and Equation Writer selects the entire expression.

You can press ► or ◄ to move laterally within the equation tree to select terms and expressions at the same level.

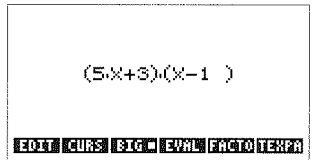
# Examples

This section includes examples of how to create specific expressions.

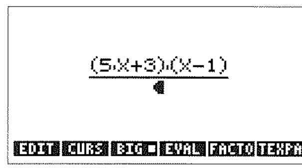
## Example 1

$$\frac{(5x+3)(x-1)}{x+1}$$

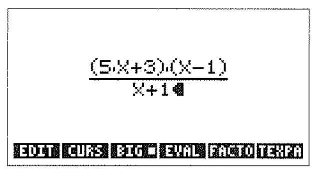
1. Enter the numerator expression.
   5 (x) (+) 3 (▶) (×) (x) (▼) (−) 1




2. Select the expression and press (÷) to insert the division bar under it.
   (▶) (▶) (▶) (÷)



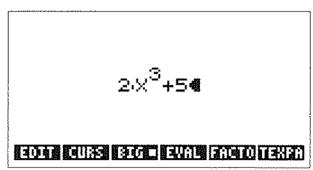

3. Enter the denominator expression.
   (x) (+) 1



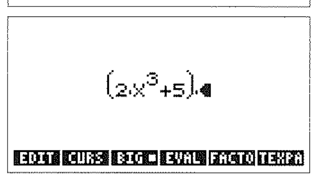

## Example 2

$$(2x^3+5)\cdot\sqrt{4x^2+2x+7}$$

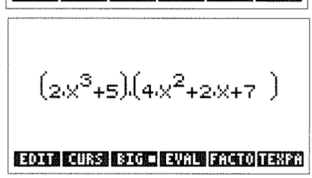
1. Enter the first component of the expression.
   2 (x) ($y^x$) 3 (▶) (▶) (+) 5



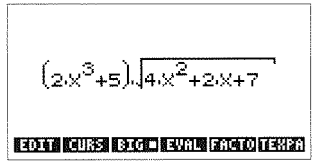

2. Select the expression, and press (×).
   (▶) (×)




3. Enter the second expression.
   4 (x) ($y^x$) 2 (▶) (▶) (+) 2 (x) (+) 7



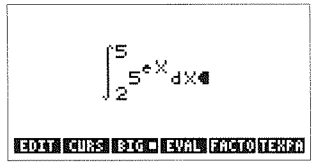
4. Select the expression and apply the square root to it.
   [▶][▶][√x]




## Example 3

$$\int_2^5 5^{ex}dx$$

1. Press the following keys:
   [↱][∫]2[▶]5[▶]5[$y^x$][ALPHA][↰]E[$x$][▶][$x$]




# Equation Writer keys

This table lists the keys you can use from within Equation Writer.

| | |
|---|---|
| [▲] | Starts Selection mode, selects terms at the next level up the equation tree. |
| [▼] | Selects the first term of the selected expression. If at the lowest level, invokes Term selection mode. |
| [↱][▼] | Invokes Term selection mode. |
| [◀] | In Term selection mode, moves the cursor left. In Selection mode, selects the term at the same level to the left. |
| [▶] | In Term selection mode, moves the cursor right. In Selection mode, selects the term at the same level to the right. |
| [↱][◀] | In Term selection mode, selects the first term in the expression. |
| [↱][▶] | In Term selection mode, selects the last term in the expression. |
| [↱][ ' ] | Puts Equation Writer into Cursor mode. |
| [SPC] | In Selection mode, selects the next component of a term. In Edit mode, enters a comma (,) character, for example, when entering a complex number. |
| [ENTER] | In Cursor mode, selects the boxed component. In any other mode, exits Equation Writer and puts the current expression onto the command line. |

# Chapter 4

# Plotting graphs

## Contents



*Cont.*

## Introduction

The HP 49G enables you to plot functions and statistical data, and to analyze the mathematical characteristics of plotted functions. Sixteen plot types are available. These are:

- function plots
- parametric plots
- polar plots
- conic plots
- differential equations
- truth plots
- slopefield plots
- wireframe plots
- pseudo-contour plots
- Y-slice plots
- gridmap plots
- parametric surface plots
- fast 3-D plots
- scatter plots
- bar graphs
- histograms

# Basic plotting

The HP 49G's plotting application enables you to graph functions. You can create the functions before opening the application, or create a function once the plotting application is open.

You can also plot statistical data. Statistical data needs to be placed in a matrix before it can be plotted. You can create the matrix before opening the plotting application, or create it once the application is open.

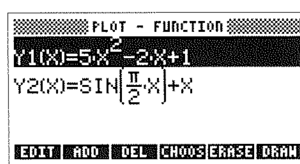
You can plot any number of functions at one time; however, you can only draw one statistical plot at a time. You can, however, superimpose a new statistical plot over a previously drawn statistical plot.

## To draw a non-statistical plot


1. Press ⓵ (2D/3D) to display the Plot Setup screen.
2. If the type of plot you want to draw is not the one shown in the Type field, press CHOOS and select a new plot type.

   You can also select a plot type by pressing (ALPHA) and the first letter of the name of the plot type. For example, to select gridmap, press (ALPHA) G. The value in the Type field changes to the plot type you selected.
3. Change whatever plotting parameters need changing.

   The parameters on the Plot Setup screen vary according to the type of plot you are drawing. They are discussed later. (See "Plot types" on page 4-6.).




4. Press ⓵ (Y=).

   The Plot – Function screen is displayed. This screen lists the functions you last plotted.
5. To delete all the functions listed, press (NXT) CLEAR.
6. To delete a particular function but keep others, use the arrow keys to highlight the function and press DEL.

   If you find you have deleted a function by accident, press (CANCEL) ⓵ (Y=).

7. To change a function:
   a. Use the arrow keys to highlight the function.
   b. Press EDIT.

      The function is displayed in Equation Writer.
   c. Edit the function.
   d. Press (ENTER).

      Equation Writer closes and your edited function overwrites the function you chose to modify.

      To cancel your edit, press (CANCEL) (↰) (Y=).
8. To choose a user-defined function:
   a. Highlight the function below which you want the new function to be placed.
   b. Press CHOOS.

      A list of user-defined functions is displayed.
   c. Highlight the function you want to plot.
   d. Press OK.

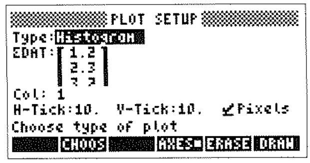
   See "User-defined functions" on page 7-4 for instructions on how to create user-defined functions.
9. To create a new function to be plotted:
   a. Press ADD to open Equation Writer.
   b. Create the function.
   c. Press (ENTER).

      Equation Writer closes and your new function is added to the list of functions to be plotted.
10. Press (↰) (WIN) to display the Plot Window screen.
11. If necessary, change the plot window parameters.

    The parameters on the Plot Window screen vary according to the type of plot you are drawing. They are discussed later. (See "Plot types" on page 4-6.)
12. The HP 49G keeps a record of your last plot. This enables you to draw a new function (or set of functions), or data matrix, over the top of an earlier function, set of functions, or data matrix. If you do not want to include the earlier plot, press ERASE.
13. To plot the function(s), press DRAW.

## To draw a statistical plot

1. Press ⬑ (2D/3D) to display the Plot Setup screen.




2. Press CHOOS and select the type of statistical plot you want to draw: bar, histogram, or scatter.
3. Press (▼) to move to the ΣDAT field.
4. Press ⬑ (MTRW) to open Matrix Writer.
5. Create a matrix to represent the statistical data you want to plot.
6. Press (ENTER).
7. The matrix you entered appears on screen within square brackets. Press OK to continue (or modify the matrix if necessary before pressing OK).
8. The HP 49G has a number of settings that determine features such as the part of the graph to be displayed, the scale of the graph, and so on. These settings are listed on the:
   - Plot Setup screen and
   - Plot Window screen (by pressing ⬑ (WIN)).

   The settings listed on these two screens vary according to the type of graph you are plotting. They are discussed later. (See "Statistical plots" on page 4-28.) If necessary, change the default or current values of these settings before plotting your data matrix.
9. The HP 49G keeps a record of your last plot. This enables you to draw a new statistical plot over the top of an earlier plot. If you do not want to include the earlier plot, press ERASE.
10. To plot the data matrix, press DRAW.

You can plot the equations listed on the Plot – Function screen, or the data saved in the ΣDAT variable, without first displaying any of the three plotting parameters screens. Just press ⬑ (GRAPH) to select the Graph command. Your equation(s) or data matrix are plotted. The parameters currently set on the Plot Window and Plot Setup input forms are used to determine the appearance of the plot.

# Plot types

This section describes the 16 plot types that the HP 49G can draw. The procedure for plotting each type is set out in the previous section ("Basic plotting").

The plot window and plot setup parameters for each plot type are provided. The input forms for setting these parameters are displayed by pressing ⬅ WIN and ⬅ 2D/3D respectively.

## Function plots

The calculator's default plot type is the function plot. A function plot plots equations that return a unique $f(x)$ for each value of $x$. An example is $y = x^3 + 2x^2 - x$.

When entering a function to be plotted, make sure that it is in the form $y = f(x)$. For example, an equation in the form $9x + y - 7 = 0$ should be entered as $-9x + 7$.

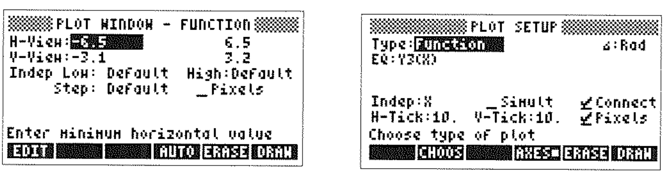


Figure 4-3: Default plot window and plot setup parameters for function plots

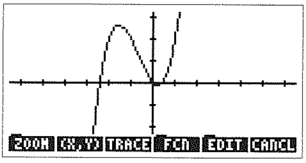


Figure 4-4: Sample function plot

### Plot window parameters

H-View — The horizontal display range, with the minimum horizontal value in the first field and maximum horizontal value in the second field.

V-View — The vertical display range, with the minimum vertical value in the first field and maximum vertical value in the second field.

| | |
|---|---|
| Low | The smallest value of the independent variable that you want plotted. |
| High | The greatest value of the independent variable that you want plotted. |
| Step | Determines the resolution of the plot. It is the horizontal distance—in units or pixels—between two plotted points. Larger step sizes provide speedier plots, but show less detail. Smaller step sizes provide more detail but take longer to draw. (For functions, the default step size is 0.2 units). See also PIXELS below. |
| Pixels | When this field is checked, the STEP value is measured in pixels. When unchecked—which is the default setting—the step value is measured in units. |
| Auto | Resets the vertical display range so that the maxima and minima within the specified horizontal display range are displayed.<br>Choose this option by pressing AUTO. The V-View fields are recalculated. |

### Plot setup parameters

| | |
|---|---|
| Type | The type of plot (in this case, *function*). |
| ∡ | The angle units field indicates the units in which angular arguments are to be interpreted: degrees, radians, or gradians. |
| EQ | The equation or list of equations you want to plot. It defaults to the equation(s) listed on the Plot Functions screen, but it can be changed on the Plot Setup input form. |
| Indep | The name of the independent variable. |
| Connect | When checked—which is the default setting—the plotted points are connected to form a line or curve; when unchecked, only the plotted points are displayed. |
| Simult | When checked, each equation listed on the Plot Functions input form is plotted simultaneously; when unchecked—which is the default setting—one equation is plotted fully before the next equation is plotted. |

H-Tick — The number of units (or pixels) between tick marks on the horizontal axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below). This field is only available if you have chosen to display axes. Press (F4) to include or exclude axes.

V-Tick — The number of pixels or units between tick marks on the vertical axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below).

This field is only available if you have chosen to display axes. Press (F4) to include or exclude axes.

Pixels — When checked—which is the default—the values in the H-Tick and V-Tick fields are interpreted as pixels. When unchecked, these values are interpreted as units.

This field is only available if you have chosen to display axes. Press (F4) to include or exclude axes.

## Parametric plots

A parametric plot is a compound of two equations, with the dependent variable in each being a function of the same independent variable. An example is $x(t) = 3\sin(3t)$ and $y(t) = 2\sin(4t)$. You need to combine both equations into the form $a + bi$ where $a$ is the first equation and $b$ is the second equation. To continue the example, you would need to specify, as the equation to plot, $3\sin(3t) + 2\sin(4t)i$.

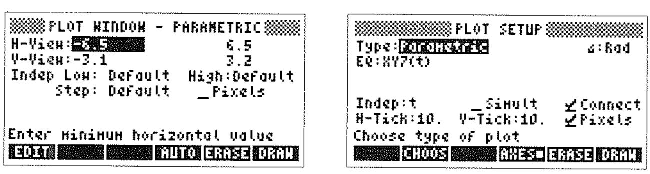



Figure 4-5: Default plot window and plot setup parameters for parametric plots

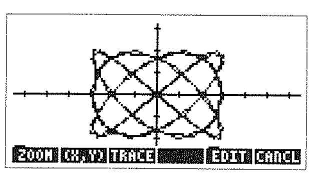



Figure 4-6: Sample parametric plot

## Plot window parameters

| | |
|---|---|
| H-View | The horizontal display range, with the minimum horizontal value in the first field and maximum horizontal value in the second field. |
| V-View | The vertical display range, with the minimum vertical value in the first field and maximum vertical value in the second field. |
| Low | The smallest value of the independent variable that you want plotted. |
| High | The greatest value of the independent variable that you want plotted. |
| Step | Determines the resolution of the plot. It is the horizontal distance—in units or pixels—between two plotted points. Larger step sizes provide speedier plots, but show less detail. Smaller step sizes provide more detail but take longer to draw. See also PIXELS below. |
| Pixels | When this field is checked, the STEP value is measured in pixels. When unchecked—which is the default setting—the step value is measured in units. |
| Auto | Resets the horizontal display range and the vertical display range so that the plot fills the screen.<br><br>Choose this option by pressing AUTO. The H-View and V-View fields are recalculated. |

## Plot setup parameters

| | |
|---|---|
| Type | The type of plot (in this case, *parametric*). |
| ∡ | The angle units field indicates the units in which angular arguments are to be interpreted: degrees, radians, or gradians. |
| EQ | The equations you want to plot. It defaults to the equations listed on the Plot – Parametric screen but it can be changed on the Plot Setup input form. |
| Indep | The name of the independent variable (usually $t$ for parametric plots). |

| | |
|---|---|
| Connect | When checked—which is the default setting—the plotted points are connected to form a line or curve; when unchecked, only the plotted points are displayed. |
| Simult | When checked, each equation listed on the Plot – Parametric input form is plotted simultaneously; when unchecked—which is the default setting—one equation is plotted fully before the next equation is plotted. |
| H-Tick | The number of units (or pixels) between tick marks on the horizontal axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below).<br>This field is only available if you have chosen to display axes. Press (F4) to include or exclude axes. |
| V-Tick | The number of pixels or units between tick marks on the vertical axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below).<br>This field is only available if you have chosen to display axes. Press (F4) to include or exclude axes. |
| Pixels | When checked—which is the default—the values in the H-Tick and V-Tick fields are interpreted as pixels. When unchecked, these values are interpreted as units.<br>This field is only available if you have chosen to display axes. Press (F4) to include or exclude axes. |

## Polar plots

A polar plot is a graph of a function described according to the polar coordinate system $f(\theta)$. The independent variable is the polar angle, $\theta$. An example is $r = 5\sin(\theta) + \sin(5\theta)$.

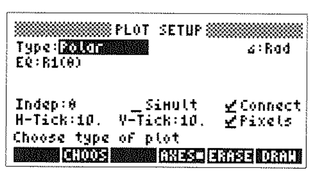



Figure 4-7: Default plot window and plot setup parameters for polar plots

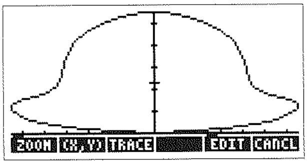



Figure 4-8: Sample polar plot

## Plot window parameters

| | |
|---|---|
| H-View | The horizontal display range, with the minimum horizontal value in the first field and maximum horizontal value in the second field. |
| V-View | The vertical display range, with the minimum vertical value in the first field and maximum vertical value in the second field. |
| Low | The smallest value of the independent variable that you want plotted. |
| High | The greatest value of the independent variable that you want plotted. |
| Step | Determines the resolution of the plot. It is the horizontal distance—in units or pixels—between two plotted points. Larger step sizes provide speedier plots, but show less detail. Smaller step sizes provide more detail but take longer to draw. See also PIXELS below. |
| Pixels | When this field is checked, the STEP value is measured in pixels. When unchecked—which is the default setting—the step value is measured in units. |
| Auto | Resets the horizontal display range and the vertical display range so that the plot fills the screen.<br>Choose this option by pressing AUTO. The H-View and V-View fields are recalculated. |

Plotting graphs

## Plot setup parameters

| | |
|---|---|
| Type | The type of plot (in this case, *polar*). |
| ∡ | The angle units field indicates the units in which angular arguments are interpreted: degrees, radians, or gradians. |
| EQ | The equation(s) you want to plot. It defaults to the equations listed on the Plot – Polar screen but it can be changed on the Plot Setup input form. |
| Indep | The name of the independent variable (usually θ for polar plots). |
| Connect | When checked—which is the default setting—the plotted points are connected to form a line or curve; when unchecked, only the plotted points are displayed. |
| Simult | When checked, each equation listed on the Plot – Polar input form is plotted simultaneously; when unchecked—which is the default setting—one equation is plotted fully before the next equation is plotted. |
| H-Tick | The number of units (or pixels) between tick marks on the horizontal axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below).<br><br>This field is only available if you have chosen to display axes. Press (F4) to include or exclude axes. |
| V-Tick | The number of pixels or units between tick marks on the vertical axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below).<br><br>This field is only available if you have chosen to display axes. Press (F4) to include or exclude axes. |
| Pixels | When checked—which is the default—the values in the H-Tick and V-Tick fields are interpreted as pixels. When unchecked, these values are interpreted as units.<br><br>This field is only available if you have chosen to display axes. Press (F4) to include or exclude axes. |

## Conic plots

Conic plots are plots of conic sections. The equation for a conic section is a polynomial of second degree or less for both $x$ and $y$. An example is $5x^2 + 3y^2 - 18 = 0$.

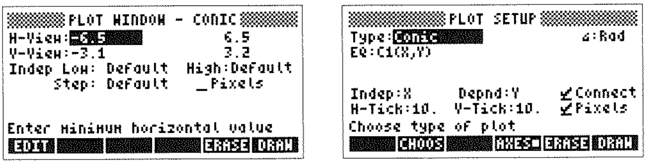



Figure 4-9: Default plot window and plot setup parameters for conic plots

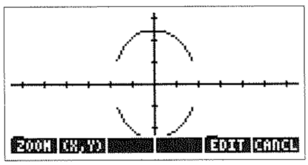



Figure 4-10: Sample conic plot

### Plot window parameters

| | |
|---|---|
| H-View | The horizontal display range, with the minimum horizontal value in the first field and maximum horizontal value in the second field. |
| V-View | The vertical display range, with the minimum vertical value in the first field and maximum vertical value in the second field. |
| Low | The smallest value of the independent variable that you want plotted. |
| High | The greatest value of the independent variable that you want plotted. |
| Step | Determines the resolution of the plot. It is the horizontal distance—in units or pixels—between two plotted points. Larger step sizes provide speedier plots, but show less detail. Smaller step sizes provide more detail but take longer to draw. See also PIXELS below. |
| Pixels | When this field is checked, the STEP value is measured in pixels. When unchecked—which is the default setting—the step value is measured in units. |

## Plot setup parameters

| | |
|---|---|
| Type | The type of plot (in this case, *conic*). |
| ∡ | The angle units field indicates the units in which angular arguments are to be interpreted: degrees, radians, or gradians. |
| EQ | The equation(s) you want to plot. It defaults to the equations listed on the Plot – Conic screen but it can be changed on the Plot Setup input form. |
| Indep | The name of the independent variable. |
| Depnd | The name of the dependent variable. |
| Connect | When checked—which is the default setting—the plotted points are connected to form a line or curve; when unchecked, only the plotted points are displayed. |
| H-Tick | The number of units (or pixels) between tick marks on the horizontal axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below).<br><br>This field is only available if you have chosen to display axes. Press (F4) to include or exclude axes. |
| V-Tick | The number of pixels or units between tick marks on the vertical axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below).<br><br>This field is only available if you have chosen to display axes. Press (F4) to include or exclude axes. |
| Pixels | When checked—which is the default—the values in the H-Tick and V-Tick fields are interpreted as pixels. When unchecked, these values are interpreted as units.<br><br>This field is only available if you have chosen to display axes. Press (F4) to include or exclude axes. |

# Differential equation plots

A differential equation is an equation that involves one or more derivatives. An example is $dy/dt = t + y$.

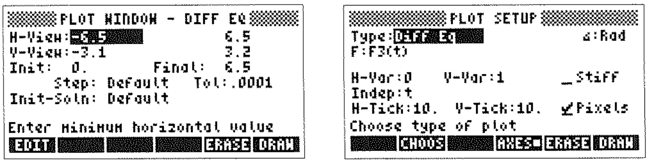



Figure 4-11: Default plot window and plot setup parameters for plotting differential equations

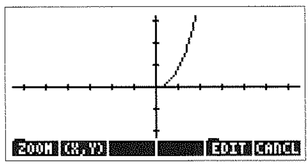



Figure 4-12: Sample differential equation plot

## Plot window parameters

| | |
|---|---|
| H-View | The horizontal display range, with the minimum horizontal value in the first field and maximum horizontal value in the second field. |
| V-View | The vertical display range, with the minimum vertical value in the first field and maximum vertical value in the second field. |
| Init | The independent variable's initial value. (This must correspond to the initial value of the solution variable.) |
| Final | The independent variable's final value. |
| Init-Soln | The solution variable's initial value. |
| Tol | An indication of acceptable tolerance, that is, the acceptable level of absolute error. (The default value is 0.0001.) |
| Step | The initial step size used to compute the solution. |

## Plot setup parameters

| | |
|---|---|
| Type | The type of plot. |
| ∡ | The angle units field indicates the units in which angular arguments are to be interpreted: degrees, radians, or gradians. |
| F | The equation(s) you want to plot. It defaults to the equations listed on the Plot – Diffeq screen but it can be changed on the Plot Setup input form. |
| Indep | The name of the independent variable. |
| Soln | The solution variable. |
| H-Var | The variable plotted on the horizontal axis. |
| V-Var | The variable plotted on the vertical axis. |
| Stiff | Check this field to select the stiff solver. |
| ∂F∂y | The partial derivative with respect to $y$ of the expression in F. |
| ∂F∂$t$ | The partial derivative with respect to $t$ of the expression in F. |
| H-Tick | The number of units (or pixels) between tick marks on the horizontal axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below).<br><br>This field is only available if you have chosen to display axes. Press F4 to include or exclude axes. |
| V-Tick | The number of pixels or units between tick marks on the vertical axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below).<br><br>This field is only available if you have chosen to display axes. Press F4 to include or exclude axes. |
| Pixels | When checked—which is the default—the values in the H-Tick and V-Tick fields are interpreted as pixels. When unchecked, these values are interpreted as units.<br><br>This field is only available if you have chosen to display axes. Press F4 to include or exclude axes. |

# Truth plots

Truth plots evaluate expressions that return a true result (that is, any non-zero real number) or a false result (that is, 0). At the coordinates of each pixel, the pixel is turned *on* if the expression is true or is left *unchanged* if the expression is false.

The following example is a plot of $x^2 + y^3 \bmod 2 < 4$.

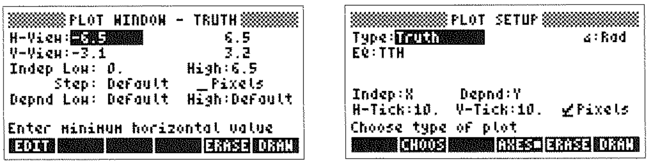



Figure 4-13: Default plot window and plot setup parameters for truth plots

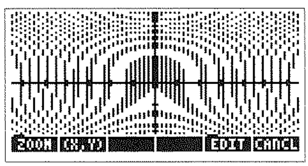



Figure 4-14: Sample truth plot

## Plot window parameters

| | |
|---|---|
| H-View | The horizontal display range, with the minimum horizontal value in the first field and maximum horizontal value in the second field. |
| V-View | The vertical display range, with the minimum vertical value in the first field and maximum vertical value in the second field. |
| Indep Low | The smallest value of the independent variable that you want plotted. |
| Indep High | The greatest value of the independent variable that you want plotted. |
| Step | Determines the resolution of the plot. It is the horizontal distance—in units or pixels—between two plotted points. Larger step sizes provide speedier plots, but show less detail. Smaller step sizes provide more detail but take longer to draw. (For truth plots, the default step size is 1 pixel). See also PIXELS below. |

Pixels — When this field is checked, the STEP value is measured in pixels. When unchecked—which is the default setting—the STEP value is measured in units.

Depnd Low — The smallest value of the dependent variable that you want plotted.

Depnd High — The largest value of the dependent variable that you want plotted.

### Plot setup parameters

Type — The type of plot (that is, *truth*).

∡ — The angle units field indicates the units in which angular arguments are to be interpreted: degrees, radians, or gradians.

EQ — The equation(s) you want to plot. It defaults to the equations listed on the Plot – Truth screen but it can be changed on the Plot Setup input form.

Indep — The name of the independent variable. It will be plotted on the horizontal axis.

Depnd — The name of the dependent variable (or second independent variable). It will be plotted on the vertical axis.

H-Tick — The number of units (or pixels) between tick marks on the horizontal axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below).

This field is only available if you have chosen to display axes. Press (F4) to include or exclude axes.

V-Tick — The number of pixels or units between tick marks on the vertical axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below).

This field is only available if you have chosen to display axes. Press (F4) to include or exclude axes.

Pixels — When checked—which is the default—the values in the H-Tick and V-Tick fields are interpreted as pixels. When unchecked, these values are interpreted as units.

# Slopefield plots

A slopefield plot draws a lattice of line segments whose slopes represent the value of the function $f(x,y)$ at their centerpoint. Slopefield plots are particularly useful in understanding antiderivatives and in solving differential equations.

A slopefield plot needs two inputs to generate an output. The HP 49G uses a two-dimensional *sampling grid* of points whose coordinates provide the two inputs required. By default, the sampling grid consists of 80 points: 10 columns by 8 rows.

The following example is a slopefield plot of $\dfrac{x^3+1}{y^2-1}$.

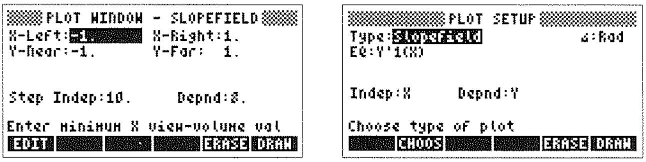



Figure 4-15: Default plot window and plot setup parameters for slopefield plots

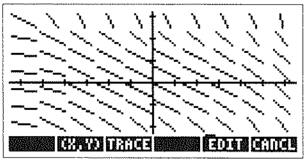



Figure 4-16: Sample slopefield plot

## Plot window parameters

| | |
|---|---|
| X-Left, X-Right | The horizontal display range corresponding to the first independent variable (entered in the Indep field). |
| Y-Near, Y-Far | The vertical display range corresponding to the second independent variable (entered in the Depnd field). |
| Step Indep | The number of columns in the sampling grid. |
| Step Depnd | The number of rows in the sampling grid. |

## Plot setup parameters

| | |
|---|---|
| Type | The type of plot (namely, *slopefield*). |
| ∡ | The angle units field indicates the units in which angular arguments are to be interpreted: degrees, radians, or gradians. |
| EQ | The equation or list of equations you want to plot. |
| Indep | The name of one of the independent variables. |
| Depnd | The name of the second independent variable. |

# Wireframe plots

A wireframe plot draws an oblique, 3-D plot of a wireframe model of a surface determined by $Z = F(x, y)$. An example is $z = x^3 - xy^3$.

The plot drawn is the surface of the model as viewed from a specified vantage point. This vantage point is called the *eyepoint*. The surface plotted is that within a region in 3-dimensional space—called the view volume—determined by ranges on each of the three coordinate axes.

A wireframe plot needs two inputs to generate an output. The HP 49G uses a two-dimensional *sampling grid* of points whose coordinates provide the two inputs required. By default, the sampling grid consist of 80 points: 10 columns by 8 rows.

The following example is a wireframe plot of $z = x^3y - xy^3$.

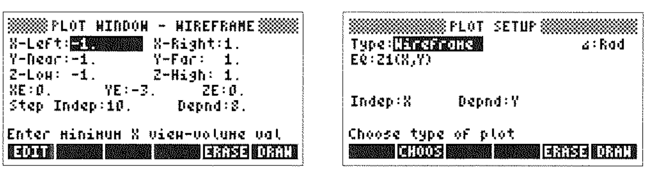



Figure 4-17: Default plot window and plot setup parameters for wireframe plots

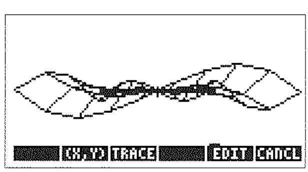



Figure 4-18: Sample wireframe plot

### Plot window parameters

| | |
|---|---|
| X-Left, X-Right | The $x$-axis range—or width—of the view volume. |
| Y-Near, Y-Far | The $y$-axis range—or depth—of the view volume. |
| Z-Low, Z-High | The $z$-axis range—or height—of the view volume. |
| XE | The $x$ coordinate of the eyepoint. |
| YE | The $y$ coordinate of the eyepoint. |
| ZE | The $z$ coordinate of the eyepoint. |
| Step Indep | The number of columns in the sampling grid. |
| Step Depnd | The number of rows in the sampling grid. |

### Plot setup parameters

| | |
|---|---|
| Type | The type of plot (in this case, *wireframe*). |
| ∡ | The angle units field indicates the units in which angular arguments are to be interpreted: degrees, radians, or gradians. |
| EQ | The equation or list of equations you want to plot. |
| Indep | The name of one of the independent variables. |
| Depnd | The name of the second independent variable. |

## Pseudo-Contour plots

A pseudo-contour plot is a lattice of line segments each tangent to a contour of a function (a curve satisfying $F(x,y)$ = constant).

A pseudo-contour plot needs two inputs to generate an output. The HP 49G uses a two-dimensional *sampling grid* of points whose coordinates provide the two inputs required. By default, the sampling grid consist of 80 points: 10 columns by 8 rows. In drawing a pseudo-contour plot, the HP 49G computes a tangent for each point in the sampling grid.

The pseudo-contour plot type produces a fast contour plot, enabling your eye to pick out the integral curves without actually plotting them.

The following example is a pseudo-contour plot of $z = x^3y - xy^3$.

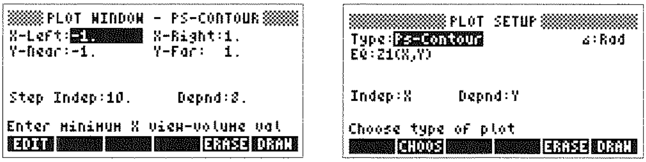



Figure 4-19: Default plot window and plot setup parameters for pseudo-contour plots

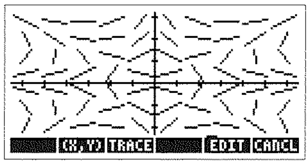



Figure 4-20: Sample pseudo-contour plot

## Plot window parameters

X-Left, X-Right — The horizontal display range corresponding to the first independent variable (entered in the Step Indep field).

Y-Near, Y-Far — The vertical display range corresponding to the second independent variable (entered in the Step Depnd field).

Step Indep — The number of columns in the sampling grid.

Step Depnd — The number of rows in the sampling grid.

## Plot setup parameters

Type — The type of plot (namely, *ps-contour*).

∡ — The angle units field indicates the units in which angular arguments are to be interpreted: degrees, radians, or gradians.

EQ — The equation or list of equations you want to plot.

Indep — The name of one of the independent variables.

Depnd — The name of the second independent variable.

# Y-Slice plots

The Y-Slice plot draws a series of cross-sections or slices—each perpendicular to the $y$-axis—of the surface determined by a specified function.

A Y-Slice plot needs two inputs to generate an output. The HP 49G uses a two-dimensional *sampling grid* of points whose coordinates provide the two inputs required. By default, the sampling grid consist of 80 points: 10 columns by 8 rows. In drawing a Y-Slice plot, the HP 49G draws one slice for each row in the sampling grid.

Once it has completed drawing all the slices, the HP 49G creates and runs an animation, with one slice per frame. This enables you to visualize a moving slice through the surface.

The following example is a Y-Slice plot of $z = x^3y - xy^3$.

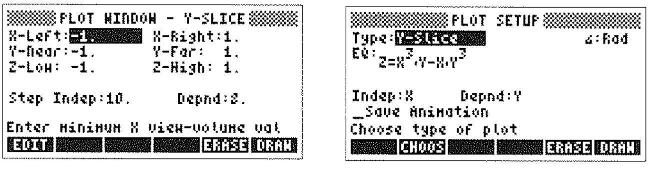



Figure 4-21: Default plot window and plot setup parameters for Y-Slice plots

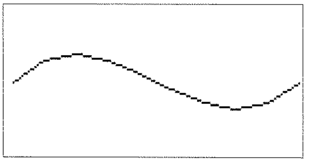


Figure 4-22: Sample slice of a Y-slice plot

## Plot window parameters

X-Left, X-Right The $x$-axis range—or width—of the view volume.

Y-Near, Y-Far The $y$-axis range—or depth—of the view volume.

Z-Low, Z-High The $z$-axis range—or height—of the view volume.

Step Indep The number of columns in the sampling grid.

Step Depnd The number of rows in the sampling grid.

## Plot setup parameters

| | |
|---|---|
| Type | The type of plot (namely, *Y-Slice*). |
| ∡ | The angle units field indicates the units in which angular arguments are interpreted: degrees, radians, or gradians. |
| EQ | The expression, equation or function you want to plot. |
| Indep | The name of one of the independent variables. |
| Depnd | The name of the second independent variable. |
| Save Animation | When checked, the series of slices used in the animation, and the number of slices, are placed in history. When unchecked, all slices except the current slice are deleted once you leave the plot window. |

# Gridmap plots

A gridmap plot transforms a specified sampling grid according to a complex-valued function. The coordinates of each point in the sampling grid are the inputs for the function.

The following example is a plot of sin(($x$, $y$)).

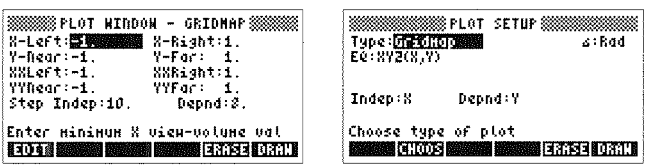



Figure 4-23: Default plot window and plot setup parameters for gridmap plots

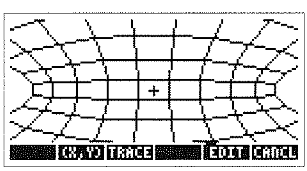



Figure 4-24: Sample gridmap plots

## Plot window parameters

| | |
|---|---|
| X-Left, X-Right | The horizontal display range. |
| Y-Near, Y-Far | The vertical display range. |
| XX-Left, | The horizontal range of the input sampling grid, |

| | |
|---|---|
| XX-Right | corresponding to the first independent variable (entered in the Step Indep field). |
| YY-Near, YY-Far | The vertical range of the input sampling grid, corresponding to the second independent variable (entered in the Step Depnd field). |
| Step Indep | The number of columns in the sampling grid. |
| Step Depnd | The number of rows in the sampling grid. |

### Plot setup parameters

| | |
|---|---|
| Type | The type of plot (namely, *gridmap*). |
| ∡ | The angle units field indicates the units in which angles are to be interpreted: degrees, radians, or gradians. |
| EQ | The equation or list of equations you want to plot. |
| Indep | The name of one of the independent variables. |
| Depnd | The name of the second independent variable. |

## Parametric surface plots

A parametric surface plot draws an oblique, 3-D plot of a wireframe model of a surface determined by a complex-valued function. This plot type combines the coordinate mapping approach of the gridmap plot (see page 4-22) with the 3-D perspective plotting of wireframe plots (see page 4-20).

The following example is a parametric surface plot of $x\cos(y)\mathbf{i} + x\sin(y)\mathbf{j} + x\mathbf{k}$.

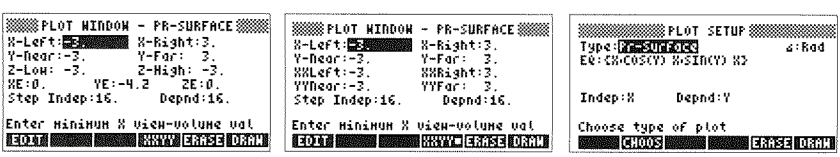



Figure 4-25: Default plot window and plot setup parameters for parametric surface plots

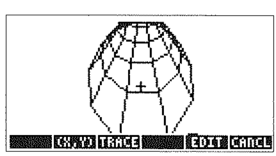



Figure 4-26: Sample parametric surface plot

## Plot window (1) parameters

| | |
|---|---|
| X-Left, X-Right | The $x$-axis range (that is, width) of the view volume. |
| Y-Near, Y-Far | The $y$-axis range (that is, depth) of the view volume. |
| Z-Low, Z-High | The $z$-axis range (that is, height) of the view volume. |
| XE | The $x$ coordinate of the eyepoint. |
| YE | The $y$ coordinate of the eyepoint. |
| ZE | The $z$ coordinate of the eyepoint. |
| Step Indep | The number of columns in the sampling grid. |
| Step Depnd | The number of rows in the sampling grid. |

## Plot window (2) parameters

The following parameters can be viewed and set by pressing XXYY. The fields replace the Z-Low, Z-High and eyepoint coordinates fields. Press XXYY again to redisplay the default Plot Window screen.

| | |
|---|---|
| XX-Left, XX-Right | The horizontal range of the input sampling grid, corresponding to the first independent variable (entered in the Indep field). |
| YY-Near, YY-Far | The vertical range of the input sampling grid, corresponding to the second independent variable (entered in the Depnd field). |

## Plot setup parameters

| | |
|---|---|
| Type | The type of plot (namely, *parametric surface).* |
| ∡ | The angle units field indicates the units in which angular arguments are to be interpreted: degrees, radians, or gradians. |
| EQ | The equation or list of equations you want to plot. |
| Indep | The name of one of the independent variable. |
| Depnd | The name of the second independent variable. |

# Fast 3-D plots

Standard 3-D functions can be plotted using the Fast 3-D plot type.

A Fast 3-D plot needs two inputs to generate an output. The HP 49G uses a two-dimensional *sampling grid* of points whose coordinates provide the two inputs required. By default, the sampling grid consist of 80 points: 10 columns by 8 rows.

The following is a Fast 3-D plot of $z = x^2y - xy^3$.

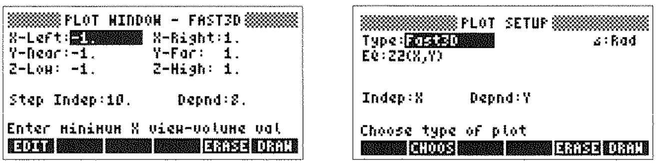



Figure 4-27: Default plot window and plot setup parameters for Fast 3-D plots

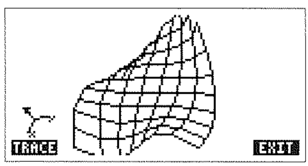



Figure 4-28: Sample Fast 3-D plot

You can rotate a Fast 3-D plot by pressing the arrow keys, or the (TOOL) and (NXT) keys.

## Plot window parameters

| | |
|---|---|
| X-Left, X-Right | The horizontal display range corresponding to the first independent variable (entered in the Indep field). |
| Y-Near, Y-Far | The vertical display range corresponding to the second independent variable (entered in the Depnd field). |
| Z-Low, Z-High | The *z*-axis range—or height—of the view volume. |
| Step Indep | The number of columns in the sampling grid. |
| Step Depnd | The number of rows in the sampling grid. |

### Plot setup parameters

| | |
|---|---|
| Type | The type of plot (namely, *fast 3-D*). |
| ∡ | The angle units field indicates the units in which angular arguments are to be interpreted: degrees, radians, or gradians. |
| EQ | The equation or list of equations you want to plot. |
| Indep | The name of one of the independent variables. |
| Depnd | The name of the second independent variable. |

## Statistical plots

You can create three types of statistical plot:

- scatter plot
- bar chart
- histogram.

Statistical plots are drawn from data you have stored in a real matrix. A quick way to enter a matrix is to use Matrix Writer. (Matrix Writer is described in chapter 8, "Vectors, lists, arrays, and matrices"). You then store the matrix in a variable and refer to that variable when plotting the data.

Only one data matrix can be plotted at one time (although you can consecutively plot different data matrices to superimpose one statistical plot over another).

The last data matrix used to draw a statistical plot is stored in a special system variable called *sigma data* (labelled ΣDAT on the screen).

## Scatter plots

A scatter plot shows the relationship between two variables by plotting an $x$–$y$ coordinate point for each item in a sample. For variables that are statistically correlated, the points should cluster along some curve.

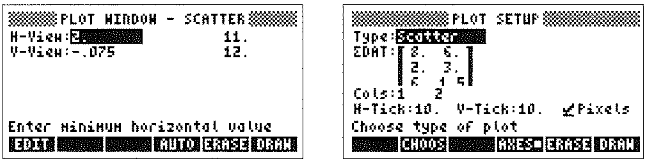



Figure 4-29: Default plot window and plot setup parameters for scatter plots

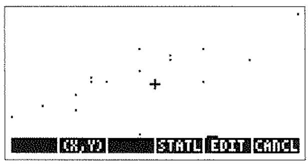



Figure 4-30: Sample scatter plot

### Plot window parameters

H-View — The horizontal display range, with the minimum horizontal value in the first field and maximum horizontal value in the second field.

V-View — The vertical display range, with the minimum vertical value in the first field and maximum vertical value in the second field.

Auto — Resets the horizontal display range to span the minimum value and the maximum value of the variable in the first Cols field, and resets the vertical display range to span the minimum value and maximum value of the variable in the second Cols field. (The Cols field is explained in the next section.)

### Plot setup parameters

| | |
|---|---|
| Type | The type of plot (namely, *scatter*). |
| ΣDAT | The data matrix, or name of the data matrix, containing the data to be plotted.<br><br>The name of a matrix is the name you gave it when you stored it as a variable. (See chapter 7, "Storing objects", for information on storing objects in variables.) The name must be entered in single quotes.<br><br>If you are entering the data matrix directly, the entire matrix, and each row of the matrix, must be enclosed in square brackets. (See chapter 8, "Vectors, lists, arrays, and matrices" for information on creating matrices.) |
| Cols | The columns of the data matrix that you want to plot. The first field indicates the column to be plotted along the horizontal axis and the second field indicates the column to be plotted along the vertical axis. |
| H-Tick | The number of units (or pixels) between tick marks on the horizontal axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below).<br><br>This field is only available if you have chosen to display axes. Press (F4) to include or exclude axes. |
| V-Tick | The number of pixels or units between tick marks on the vertical axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below).<br><br>This field is only available if you have chosen to display axes. Press (F4) to include or exclude axes. |
| Pixels | When checked—which is the default—the values in the H-Tick and V-Tick fields are interpreted as pixels. When unchecked, these values are interpreted as units.<br><br>This field is only available if you have chosen to display axes. Press (F4) to include or exclude axes. |

## Bar charts

A bar chart provides a visual representation of the relative magnitudes of the values in a specified column of a data matrix.

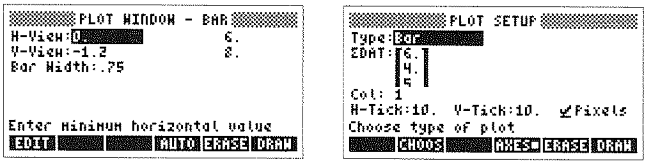



Figure 4-31: Default plot window and plot setup parameters for bar charts

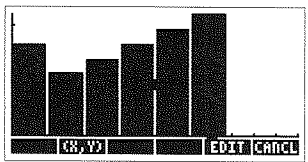



Figure 4-32: Sample bar chart

### Plot window parameters

| | |
|---|---|
| H-View | The horizontal display range, with the minimum horizontal value in the first field and maximum horizontal value in the second field. |
| V-View | The vertical display range, with the minimum vertical value in the first field and maximum vertical value in the second field. |
| Bar Width | The width of each bar. The default setting is one unit. |
| Auto | Resets the horizontal display range to fit the total number of elements in the Col field, and resets the vertical display range to span from the minimum value to the maximum value of the elements in the Col field. |

### Plot setup parameters

| | |
|---|---|
| Type | The type of plot (that is, *bar chart*). |
| ∑DAT | The data matrix, or name of the data matrix, containing the data to be plotted.<br><br>The name of a matrix is the name you gave it when you stored it as a variable. (See chapter 7, "Storing objects", for information on storing objects in variables.) If you are entering the data matrix directly, the entire matrix, and each row of the matrix, must be enclosed in square brackets. (See chapter 8, "Vectors, lists, arrays, and matrices" for information on creating matrices.) |
| Col | The column of the data matrix that you want to plot. |
| H-Tick | The number of units (or pixels) between tick marks on the horizontal axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below).<br><br>This field is only available if you have chosen to display axes. Press (F4) to include or exclude axes. |
| V-Tick | The number of pixels or units between tick marks on the vertical axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below).<br><br>This field is only available if you have chosen to display axes. Press (F4) to include or exclude axes. |
| Pixels | When checked—which is the default—the values in the H-Tick and V-Tick fields are interpreted as pixels. When unchecked, these values are interpreted as units.<br><br>This field is only available if you have chosen to display axes. Press (F4) to include or exclude axes. |

Plotting graphs

## Histograms

A histogram is a representation of a frequency distribution. The length of each bar in a histogram indicates how many items fall within its range.

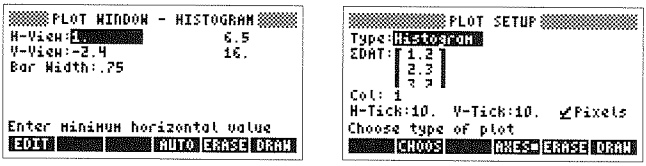



Figure 4-33: Default plot window and plot setup parameters for histograms

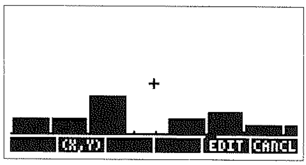



Figure 4-34: Sample histogram

### Plot window parameters

| | |
|---|---|
| H-View | The horizontal display range, with the minimum horizontal value in the first field and maximum horizontal value in the second field. |
| V-View | The vertical display range, with the minimum vertical value in the first field and maximum vertical value in the second field. |
| Bar Width | The width of each bar. The default setting is one unit |
| Auto | Resets the horizontal display range to span from the minimum value to the maximum value of the elements in the Col field, and resets the vertical display range to span from zero to the total number of rows in ΣDAT. |

### Plot setup parameters

| | |
|---|---|
| Type | The type of plot. |
| ΣDAT | The data matrix, or name of the data matrix, containing the data to be plotted. |

The name of a matrix is the name you gave it when you stored it as a variable. (See chapter 7, “Storing objects”, for information on storing objects in variables.) If you are entering the data matrix directly, the entire matrix, and each row of the matrix, must be enclosed in square brackets. (See chapter 8, "Vectors, lists, arrays, and matrices" for information on creating matrices.)

Col — The column of the data matrix that you want to plot.

H-Tick — The number of units (or pixels) between tick marks on the horizontal axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below).

This field is only available if you have chosen to display axes. Press F4 to include or exclude axes.

V-Tick — The number of pixels or units between tick marks on the vertical axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below).

This field is only available if you have chosen to display axes. Press F4 to include or exclude axes.

Pixels — When checked—which is the default—the values in the H-Tick and V-Tick fields are interpreted as pixels. When unchecked, these values are interpreted as units.

This field is only available if you have chosen to display axes. Press F4 to include or exclude axes.

# Cursor movement

With the plot screen displayed, you can move the cursor in one of two ways:

- standard graphics mode
- trace mode.

## Standard cursor movement

In standard graphics mode, the cursor moves independently of the plot. That is, pressing ◄, ▼, ►, ▲, causes the cursor to move parallel to an axis in the direction indicated by the key.

## Tracing a plot

In trace mode, the cursor jumps from plotted point to plotted point along the function when you press the ◄ or ► key. (The points that are plotted depend on the step value set on the Plot Window input form.)

Where multiple functions have been plotted, pressing ▼ or ▲ moves the cursor from function to function.

Trace mode is available for function, polar, and parametric plots. To activate trace mode, press TRACE.

You would typically choose trace mode to determine the coordinates of the points plotted (as explained in the next section). You can also display plotted coordinates in tabular form. You do this by pressing ⬅ TABLE when the plot is not displayed. See "Tables" on page 4-40 for more information.

Deactivate trace mode by pressing TRACE again. (Trace mode is automatically deactivated if you choose a ZOOM function, or any other function that causes the plot to be redrawn.)

## Cursor coordinates

To display the coordinates of the cursor, press F2 to select (X, Y). The menu is replaced by the coordinates of the cursor.

As you move the cursor, the coordinates of the cursor's current position is displayed. If you had turned on trace mode before pressing F2, the coordinates of consecutive plotted points are displayed as you press the ◄ or ► key. (Plotted points are points that correspond to the values of the independent variable as determined by the step value.)

Note that you cannot choose trace mode while you have the cursor coordinates displayed. You must choose trace mode *before* you choose to display the cursor's coordinates.

To redisplay the menu—thereby hiding the cursor coordinates—press ⊕. (The ⊕ and ⊖ keys enable you to display and hide the menu respectively. You can also redisplay the menu by pressing a function key.)

# Zooming

The **ZOOM** functions enable you to look at a particular region of the plot in more detail (by zooming in) or look at more of the plot than is currently displayed (by zooming out).

## To zoom in

1. Press ZOOM. The ZOOM menu is displayed.
2. Press ZIN to select ZOOM IN.

You can also zoom in on a rectangular area of the plot you specify. To specify the area:

1. Press ZOOM. The ZOOM menu is displayed.
2. Use the arrow keys to position the cursor at a corner of the rectangular area that you want to zoom in on.
3. Press BOXZ to select BOX ZOOM.
4. Press the appropriate arrow keys to create a box around the area you want to zoom in on.
5. Press ZOOM. The calculator zooms in on the boxed area.

## To zoom out

1. Press ZOOM. The ZOOM menu is displayed.
2. Press ZOUT to select ZOOM OUT.

## Zoom options

A number of zoom options are available from the ZOOM menu. You display the ZOOM menu from the plotting screen by pressing ZOOM. The main options are set out below.

### Setting the zoom factor

You can set the factor by which you zoom in or zoom out by changing the values on the Zoom Factors input form.

1. Press ZFACT to select ZOOM FACTOR.
2. Change the values in the H-Factor and V-Factor fields.

   Keep the values you enter the same if you want zooming to be horizontally and vertically proportional. (See also "Forcing a proportional zoom" below.)
3. If you want zooming to center around the position of your cursor, check the Recenter at Crosshairs field.
4. Press OK.

### Forcing a proportional zoom

Press ZSQR to select ZOOM SQUARE.

The plot is redrawn with the vertical scale the same as the horizontal scale.

### Resetting the zoom default

Press ZDFLT to select ZOOM DEFAULT. The plot is redrawn using the default display ranges.

## Analyzing functions

The HP 49G provides numerous tools for analyzing the mathematical properties of functions. For example, you can calculate roots, extrema, slopes, areas, and the point of intersection of two graphs.

Where you have plotted more than one function, you may first need to select the function you want to analyze. By default, the first function listed on the Plot Functions screen is the function that is selected.

To select another function for analysis:

1. Press TRACE to turn on trace mode. (See "Tracing a plot" on page 4-35.)
2. Press ▲ or ▼ until the cursor is on the function you want to analyze.

You can also select another function by pressing NXEQ (found on the second page of the FUNCTION menu). In this case, you do not need to be in trace mode.

### Function analysis tools list

The tools discussed below are available from the FUNCTIONS sub-menu (labeled FCN on the PICT menu).

1. Press FCN to display the FUNCTIONS menu.
2. Press the function key for the analysis tool you want.

When you choose a function analysis tool, the menu is hidden to make room for the result. You can restore the menu by pressing any one of the function keys: F1 to F6.

## Finding roots

A root is a point where a graph meets or crosses the $x$ axis. To find the root closest to the cursor, press ROOT on the FUNCTIONS menu.

If the root is within the display area, the cursor moves to the root and the value of the root is displayed near the bottom left corner of the screen. If the root is not within the display area, the cursor remains where it is, the message OFF SCREEN is briefly displayed, and the value of the root is displayed near the bottom left corner of the screen.

If you want to find another root, move the cursor so that it is closer to that root than to any other root before selecting ROOT.

The message "Constant?" appears on the screen if the same value was calculated at every sample point.

## Finding extrema

An extremum is the maximum or minimum value. To find the extrema closest to the cursor, press EXTR on the FUNCTIONS menu.

If an extremum is within the display area, the cursor moves to the point and the $x$ and $y$ coordinates of the extremum are displayed near the bottom left corner of the screen. If the extremum is not within the display area, the cursor remains where it is, the message OFF SCREEN is briefly displayed, and the $x$ and $y$ coordinates of the extremum are displayed near the bottom left corner of the screen.

If the derivative changes sign at the extremum, the message "Sign Reversal" briefly appears on the screen before the coordinates are displayed.

## Finding slopes

The slope tool displays the slope of the function at the $x$ value of the cursor and moves the cursor to the point on the function where the slope was calculated. To find the slope, press SLOPE on the FUNCTIONS menu.

If the point is not within the display area, the cursor remains where it is, the message OFF SCREEN is briefly displayed, and the slope of the point is displayed near the bottom left corner of the screen.

## Finding areas

The area tool displays the area between a curve and the $x$ axis between two $x$ values that you select.

1. Move the cursor so that it is over the graph at one end of the area that you want to calculate.
2. Press (X).
3. Move the cursor until it is over the graph at the other end of the area that you want to calculate.
4. Press AREA on the FUNCTIONS menu.

   The area is displayed near the bottom left corner of the screen.

## Finding intersections

The intersection tool displays the coordinates of the intersection between two functions, or between a function and the $x$ axis.

The intersection tool determines the intersection of the currently selected function and the function that follows it on the Plot Functions screen. If you have more than two functions plotted, you may need to select another function, or change the order of the functions listed on the Plot Function screen. (You can change the order of the functions listed by pressing MOVE↓ or MOVE↑, on the second page of the function key menu on the Plot Function screen.)

If two functions intersect at more than one point, the result is the coordinates of the intersection closest to the cursor. If only one function is plotted, the result is the coordinates of the intersection of the function and the $x$-axis.

To find the intersection, press INTER from the FUNCTIONS menu.

If the intersection is within the display area, the cursor moves to the intersection and the coordinates of the intersection are displayed near the bottom left corner of the screen.

If the intersection is not within the display area, the cursor remains where it is, the message OFF SCREEN is briefly displayed, and the coordinates of the intersection are displayed near the bottom left corner of the screen.

# Tables

If you have chosen to display the coordinates of the cursor while in trace mode, you can read the coordinates of consecutive plotted points by pressing the ▶ or ◀ key. This is explained in "Cursor movement" on page 4-35.

You can also display the coordinates of plotted points in tabular form. The Tables function—selected by pressing ⬑ TABLE—shows the value of the dependent variable for each value of the independent variable within the range specified on the Plot Window input form. The values of the independent variable are listed in increments determined by the step value (also specified on the Plot Window input form).

If you have plotted more than one function, the values of the independent variable for each function is given, each in a separate column.

## Customizing table values

The default values for the independent variable are taken from the parameters on the Plot Window input form. You can override these defaults by specifying a different starting value and step increment.

To change the default table values:

1. Press ⬑ TBLSET to select TABLE SETUP.
   The Table Setup input form is displayed.
2. To have the calculator automatically generate the series of values for the independent variable, specify a starting value and step value.
3. If you want to specify values for the independent variable, choose BUILD YOUR OWN rather than AUTOMATIC as the type of table.
4. Press ⬑ TABLE to select TABLE.
   If you chose an automatic table, the table values are redrawn according to the start and step values you specified.

If you chose to build your own table, the previous values are displayed. Press ⓡ CLEAR to clear these values, and then enter values in the independent variable column. As you enter values, corresponding values for the dependent variables are displayed.

# Special plotting and table variables

All the information about a plot is automatically stored in a set of reserved variables that you have direct access to. These variables are named *EQ*, *ΣDAT*, *PPAR*, *VPAR*, *ΣPAR*, and *ZPAR*. Similarly, the information regarding tables is automatically stored in *TPAR*.

Although these variables are *reserved*—which means that you should not use them as the name of some object you create—you can have different versions of these variables, providing that each version is in a separate directory.

## EQ

EQ contains the current equation or the name of the variable containing the current equation. Specifically, EQ can contain:

- A single algebraic object or the name of a variable containing a single algebraic object.
- A real number—or complex number in the case of a parametric plot—or the name of a variable containing a real or complex number.
- A program that takes no parameters and yields exactly one result, or the name of a variable that contains such a program.
- A list containing any combination of the these possibilities.

## ΣDAT

ΣDAT contains the current data matrix for statistical plots or the name of the variable that contains the data matrix. It is the equivalent of EQ when you are plotting a scatter plot, bar chart, or histogram.

## PPAR

PPAR stores the plot window and plot setup parameters for non-statistical plots. It is displayed as a list. In general, the objects in this list are:

{ $(x_{\min}, y_{\min})$, $(x_{\max}, y_{\max})$, *independent variable*, *resolution*, *(axes-intersection coordinates)*, *plot type*, *dependent variable* }

Plotting graphs

The values in the list vary according to the type of plot. They are the parameters you find on the Plot Window input form and Plot Setup input form for the particular plot type.

## VPAR

VPAR stores the view volume, eyepoint and plotting density parameters for 3-D plots. It is displayed as a list. In general, the objects in this list are:

$$\{ x_{\text{left}}, x_{\text{right}}, y_{\text{near}}, y_{\text{low}}, z_{\text{low}}, z_{\text{high}}, xx_{\text{left}}, xx_{\text{right}}, yy_{\text{left}}, yy_{\text{right}}, x_{\text{eyepoint}}, y_{\text{eyepoint}}, z_{\text{eyepoint}}, \textit{grid columns}, \textit{grid rows} \}$$

## ΣPAR

ΣPAR stores the plot window and plot setup parameters for statistical plots. (See pages page 4-29 to page 4-34 for information about these parameters.)

## ZPAR

ZPAR stores zoom information. It is displayed as a list, with the following parameters as elements:

{ *horizontal scale, vertical scale, recenter flag* }

These fields are described in "Setting the zoom factor" on page 4-37. In some instances, the list will include the *PPAR* variable as a final element.

## TPAR

Plotting graphs

TPAR stores the table setup parameters. These are:

{ *starting value, step, table format, zoom factor, font size, filename* }

# Chapter 5

# Working with expressions

## Contents

## Introduction

This chapter explains how to use the main features of the HP 49G's computer algebra system to work with expressions.

It describes how to:

- factorize, expand, and simplify expressions
- use the calculus functions to perform differentiations and integrations
- perform a differentiation in step-by-step mode.

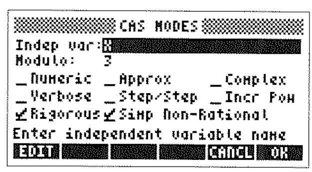
You can use either Equation Writer or the command line to create and edit expressions. The examples in this chapter do not explain how to create the expressions. See chapter 2, "Basic operation", and chapter 3, "Creating and editing expressions", for information on how to do this.

# Configuring the CAS

The HP 49G has powerful symbolic capabilities. It can return numeric or symbolic solutions to problems involving algebraic objects. You use the CAS Modes input form to set the way that the HP 49G deals with calculations, and how it performs symbolic manipulation.

To configure the CAS:

1. Press (MODE) to display the Calculator Modes input form, then press CAS. The CAS Modes input form is displayed.




2. Use the arrow keys to navigate around the options.
   - For those options that require a value, enter the value and press OK to apply it to the option.
   - For the other options, select or de-select them by pressing CHK.
3. When you have configured the CAS modes, press OK twice to return to the default screen.

On the CAS Modes input form, two key settings determine how the HP 49G handles symbolic solutions. These are the Numeric option and the Approx option.

## Numeric option

When the Numeric option is set, the calculator returns only numeric solutions to calculations. Otherwise, the calculator returns symbolic solutions.

With the numeric option set, any variables that a calculation contains must exist in the current path, and contain a numeric value. If this is not the case, the calculator returns an error. Any constants with an approximate numeric value, such as π, are evaluated and the approximate value substituted into the calculation.

For example, consider the calculation `SIN(2*π*X + 3*π*X)`

- If the Numeric option is set, and a numeric value for X is stored in the current path, the calculator returns the approximate answer, accurate to 12 decimal places. That is, it substitutes the numeric value for X and the approximate value for π into the equation.
- If the Numeric option is set and there is no numeric value for X stored in the current path, the calculator returns an error.
- If the Numeric option is clear, and no value for *X* is stored in the current path, the calculator simplifies the expression and returns `SIN(5.X.π)`.

## Approx option

The Approx option setting determines how the HP 49G expresses answers to calculations:

- When the Approx option is clear, the HP 49G finds exact solutions to calculations where possible. That is, it expresses the solution as an irreducible expression containing exact terms.
- When the Approx option is set, the HP 49G expresses solutions to 12-digit accuracy.

Note that you can change the setting of the Approx option by using the CAS Modes input form or by pressing simultaneously ⬏ and ENTER.

- If the calculator is in exact mode, pressing ⬏ ENTER changes to approximate mode.
- If the calculator is in approximate mode, pressing ⬏ ENTER changes the setting to exact mode.

Working with expressions

For example, consider the expression $\sin(x^3 + 2x)$.

If the value for variable *X* is defined as $\sqrt{2}$ in the current path:

- When the Approx option is set, evaluating the expression returns –.586176193022
- When Approximate mode is clear, evaluating the expression returns SIN(4$\sqrt{2}$).

## Other options

In addition to the above options, the CAS Modes input form is used to set the following parameters:

- **Independent variable**

  The independent variable is the default variable that the calculator uses for operations such as differentiation and integration. The default value is X.

- **Modulo**

  Enter the modulus that you want to use in modulo arithmetic operations. The default value is 3.

- **Complex**

  Check this option if you want to work with complex numbers. If you do not need to use complex numbers, de-select this option. Some transformations behave differently in complex mode.

  If complex mode is not set and a calculation returns only a complex solution for most calculations, the calculator prompts for a switch to complex mode.

- **Verbose**

  Check this option to display messages that indicate progress as the calculator performs the operations that you specify.

- **Step/step**

  Check this option to perform linear algebra operations, integrations, and differentiations in step-by-step mode. See “Differentiating an expression step-by-step” on page 5-19.

- **Incr Pow**

  Check this option to display polynomial expressions with the terms in increasing power order, for example $x + x^2 + x^3$. The default is to display polynomials with the terms in decreasing order.

- **Rigorous**

  Check this option to specify that you do not want $|x|$ terms simplified to $x$.

- **Simp Non-Rational**

  Check this option to specify that non-rational expressions are simplified.



# Using the computer algebra system

The HP 49G computer algebra system consists of a collection of commands and functions that you apply to expressions. Commands and functions appear in the same way on the menus, but they differ in the way that they operate.

Commands have the following properties:

- They produce one result.
- They cannot be included in an algebraic object.

Functions have the following properties:

- They can produce more than one result.
- They can be a part of an algebraic expression.
- You need to evaluate functions in order to get results. That is, once you apply a function to an object, you need to press EVAL, or use the EVAL command, in order to get a result.

See the *Advanced User's Guide* or the *Pocket Guide* for details of whether an operation is a function or a command.

In this chapter, commands and functions are referred to collectively as commands.

The following is a list of the categories and how you access commands in each category. Within each category, commands are displayed in a choose list.

Working with expressions

| | |
|---|---|
| (↱) (ALG) | Displays the algebraic commands, for performing operations such as factorizing or expanding. |
| (↰) (ARITH) | Displays the complex, the integer, and polynomial arithmetic commands. |
| (↰) (CALC) | Displays the calculus commands for performing operations such as integrating and differentiating. This category also includes commands for working with limits and series, and for dealing with Taylor polynomials. |
| (↱) (CMPLX) | Displays the commands relating to complex numbers. |
| (↰) (EXP&LN) | Displays the commands for manipulating exponential and logarithmic expressions. |
| (↰) (MATRICES) | Displays the commands for working with matrices. |
| (↰) (S.SLV) | Displays the commands you use to solve an equation symbolically. |
| (↱) (TRIG) | Displays the commands for manipulating trigonometric expressions. |

For example, if you want to simplify a trigonometric expression, you press (↱) (TRIG) to display the trigonometric commands.

You can use the computer algebra system to manipulate expressions both from the command line and from within Equation Writer.

- From the command line, you place the expression between the command's parentheses.
- Within Equation Writer, you select the expression, or part of the expression, then select a command from the menu.

## Working from the command line

1. Use one of the listed key combinations to display the choose list containing the command that you want.
2. Use the arrow keys to highlight the command to use, and press ENTER to place it on the command line. The command appears with a set of parentheses after it.
3. Ensure that the cursor is between the command's parentheses and insert the expression to operate on, and any other arguments the command needs. Separate each argument with a comma (⬏ ,).
4. Press ENTER to apply the command.

### Inserting an expression onto the command line

There are three ways to insert an expression onto the command line:

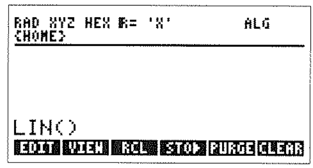
- Use the command line editor to enter the expression directly onto the command line.
- Use Equation Writer:
  a. Place the cursor where you want to insert the expression.
  a. Press EQW to open Equation Writer.
  b. Create the expression.
  c. Press ENTER to exit Equation Writer and place the expression on the command line at the cursor position.
- Retrieve an expression stored in memory or from the history. See Chapter 2, "Basic operation", and chapter 7, "Storing objects", for details.

## Command line example

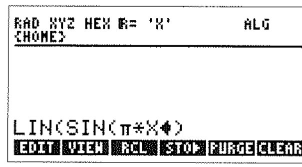
This example uses the LIN command to linearize a trigonometric expression, and the EXPAND command to simplify the result. The expression to linearize is:
$\sin(\pi x)$

Before you start, ensure that the CAS Modes input form is set to the default setting. See "Configuring the CAS" on page 5-2 for details.

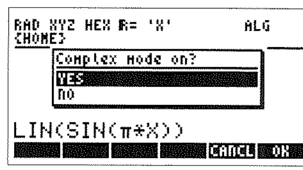
1. Open the EXP&LN menu and select the LIN command.
   ⬅ EXP&LN ▼ ▼ ENTER



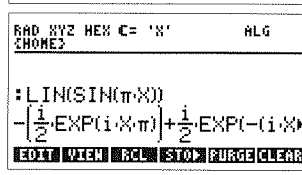

2. Enter the expression inside the command's brackets.
   SIN ⬅ π X x



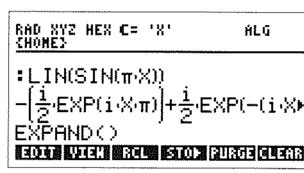

3. Apply the command to the expression.
   ENTER



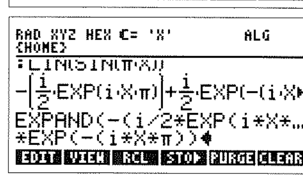

4. Since the linearization returns a complex result, the calculator prompts to switch to complex mode. Accept the switch to complex mode, and linearize the expression.
   ENTER



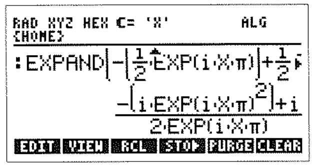

5. Open the Algebra menu and place the EXPAND command on the command line.
   ➡ ALG ENTER




6. Retrieve the result from history.
   HIST ENTER



7. Apply the command to simplify the result.
   (ENTER)




## Working in Equation Writer

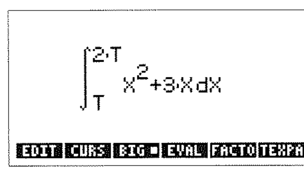
In Equation Writer, you can apply a computer algebra command to the entire expression, or you can select a part of the expression to apply a command to. See chapter 3, “Creating and editing expressions”, for details on how to use Equation Writer.

In Equation Writer, you can use only those commands that require one argument, and you cannot use commands that return more than one result.

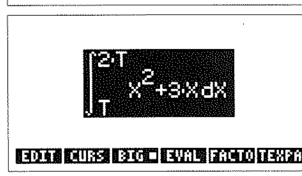
The following example demonstrates how to use Equation Writer to evaluate the integral of an expression between two indefinite limits, and factorize a part of the result. The expression to evaluate is:

$$\int_{t}^{2t} (x^2 + 3x)dx$$

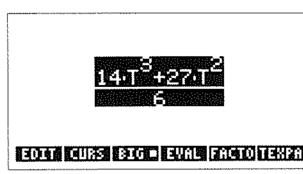
1. Open Equation Writer and enter the expression.
   (EQW) . . .



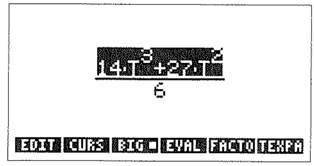

2. Select the expression.
   (▲)(▲)



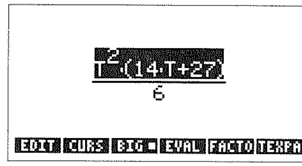

3. Evaluate the expression
   EVAL



4. Select the numerator component of the expression.
   [▲]




5. Factorize the numerator.
   FACTO



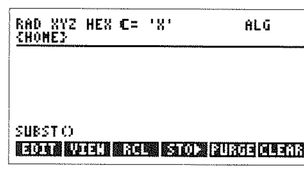

# Performing substitutions

Use the SUBST command in the algebraic command list ([⮣] [ALG]) to perform substitutions.

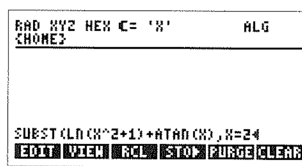
The following example substitutes the value 2 for $x$ in

$\ln(x^2 + 1) + \operatorname{atan}(x)$

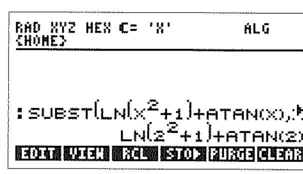
1. From the Algebra menu, select the SUBST command and place it on the command line.
   [⮣] [ALG] 6 [ENTER]



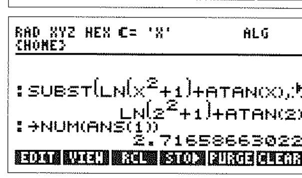

2. Use the command line editor to place the arguments between the command's parentheses.
   [⮣] [LN] [x] [$y^x$] 2 [+] 1 [▶] [+] [⮢] [ATAN] [x] [▶]
   [⮣] [,] [x] [⮣] [=] 2




3. Apply the command.
   [ENTER]

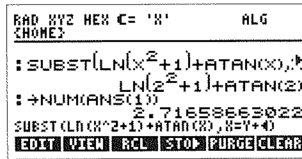



4. Because the calculator is in exact mode, the command produces the following exact result. Obtain an approximate result.
   [⮣] [→NUM] [ENTER]

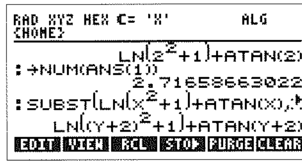


You can also use the SUBST command to substitute expressions. For example, to substitute the expression $y$+2 for $x$ in the previous example:

1. Retrieve the original command from history and edit it to replace the substitution value.
   HIST ▲ . . ENTER . . ◄ ◄ ◄ ALPHA Y + 2



2. Apply the command.
   ENTER



# Expanding and factorizing

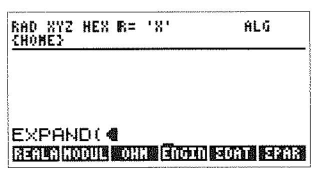
The HP 49G can expand and factorize most algebraic expressions. The commands that perform these functions are in the algebraic category. If the expression that you are working on contains exponential or trigonometric functions, you may need to simplify the expression before using EXPAND or FACTOR. See “Exponential and trigonometric expressions” on page 5-14.

## Expanding expressions

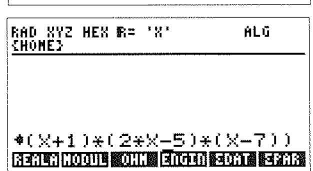
You use the EXPAND command to expand and simplify an expression. The following example expands the expression:

$$(x+1)(2x-5)(x-7)$$

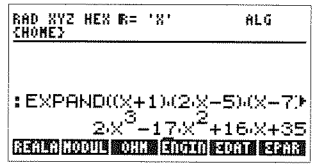
1. Open the Algebra command list and select EXPAND to place it on the command line.
   ↱ ALG ENTER



2. With the cursor between the parentheses, open Equation Writer and create the expression. When you have created it, press ENTER to place it on the command line between the parentheses.
   EQW . . . ENTER



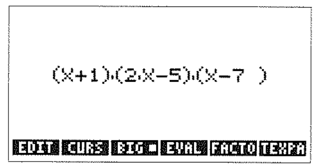
3. Press (ENTER) to expand the expression.
   (ENTER)



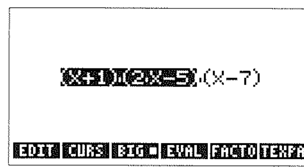

## Expanding a part of the expression

To expand parts of the expression, you must work from within Equation Writer. For example, to expand the first two components of the expression in the previous example, perform the following.

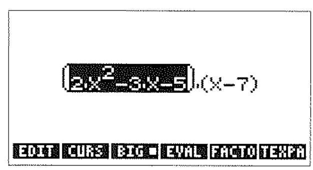
1. Open Equation Writer and create the expression.
   (EQW) . . .




2. Use either Cursor mode or Selection mode to select the first two component expressions only. For example, if the cursor is positioned on the first term in the expression, X, use the following keystrokes.
   (▲)(▲)(↱)(▶)




3. Open the Algebra command list and select EXPAND to expand the selected components.
   (↱)(ALG)(ENTER)



# Factorizing expressions

You use the FACTOR command to factorize an expression. As with EXPAND, you can factorize an entire expression, or components of the expression.



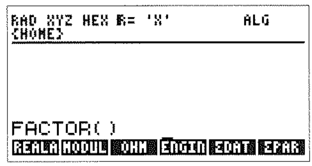
## Example

This example factorizes the following cubic polynomial expression:

$$2x^3 + 5x^2 - 8x - 20$$

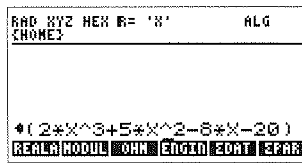
1. Open the Algebra command list and select FACTOR.

   (↱)(ALG)(▼)(ENTER)



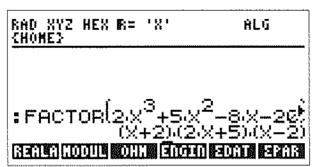

2. With the cursor positioned between the parentheses, open Equation Writer, create the expression, and press (ENTER) to place it on the command line between the parentheses.

   (EQW) … (ENTER)




3. Press (ENTER) to factorize the expression.

   (ENTER)

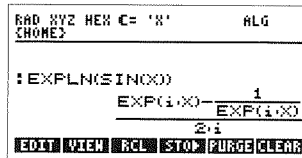


## Exponential and trigonometric expressions

When working with expressions involving exponential and trigonometric functions, you often need to simplify them before you use FACTOR or EXPAND. The following commands, from the exponential and linearization category, simplify trigonometric and exponential expressions. At the beginning of each description, the keys you use to access the command list are displayed.

EXPLN — Exp and Lin command list—(⇦) (EXP&LN):

Applies Euler identity. The example at the right shows the result of applying the command to sin($x$).




HALFTAN — Trigonometry command list—(⇨) (TRIG)

Replaces sin($x$), cos($x$), and tan($x$) terms with terms that use $\tan\frac{x}{2}$.

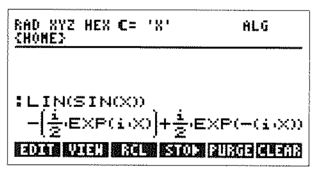
LIN — Exp and Lin command list—(⇦) (EXP&LN)

Performs Euler identities, then linearizes expressions by applying the following substitutions:

$$e^x \cdot e^y \rightarrow e^{x+y}$$

$$(e^x)^n \rightarrow e^{nx}$$

The example at the right shows the result of applying the command to sin($x$).




LNCOLLECT — Exp and Lin command list—(⇦) (EXP&LN)

Simplifies an expression by collecting terms involving natural logarithms.

SINCOS — Trigonometry command list—(⇨) (TRIG)

Converts exponential and natural logarithmic expressions to trigonometric expressions.

| | |
|---|---|
| TAN2SC | Trigonometry command list—(↱) (TRIG) |

Applies the following substitution:

$$\tan(x) \to \frac{\sin(x)}{\cos(x)}$$

| | |
|---|---|
| TAN2SC2 | Trigonometry command list—(↱) (TRIG) |

Applies the following substitutions:

$$\tan(x) \to \frac{\sin(2x)}{1 + \cos(2x)}$$

$$\tan(x) \to \frac{1 - \cos(2x)}{\sin(2x)}$$

| | |
|---|---|
| TEXPAND | Trigonometry command list—(↱) (TRIG) |

Expands expressions of the form Exp($nx$), sin($nx$), and cos($nx$), where $n$ is an integer. It applies the following substitutions:

$$e^{x+y} \to e^x e^y$$

$$\ln(xy) \to \ln(x) + \ln(y)$$

$$\sin(x + y) \to \sin(x)\cos(y) + \sin(y)\cos(x)$$

$$\cos(x + y) \to \cos(x)\cos(y) - \sin(x)\sin(y)$$

| | |
|---|---|
| TLIN | Trigonometry command list—(↱) (TRIG) |

Applies the following substitution:

$$\sin(x)\sin(y) = \frac{1}{2}(\cos(x - y) - \cos(x + y))$$

| | |
|---|---|
| TRIG | Trigonometry command list—(↱) (TRIG) |

Simplifies expressions by applying the following substitution:

$$\sin^2(x) + \cos^2(x) = 1$$

TRIGCOS — Trigonometry command list—(↱)(TRIG)

Applies the following substitution, and returns cosine terms if possible:

$$\sin^2(x) \rightarrow 1-\cos^2(x)$$

TRIGSIN — Trigonometry command list—(↱)(TRIG)

Applies the following substitution, and returns sine terms if possible:

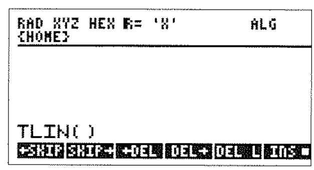
$$\cos^2(x) \rightarrow 1-\sin^2(x)$$

## Example

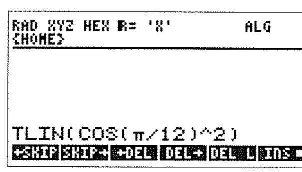
This example uses TLIN, in conjunction with EXPAND, to simplify the following trigonometric expression, and deduce its value:

$$\left(\cos\frac{\pi}{12}\right)^2$$

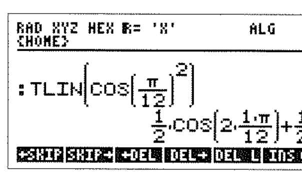
1. Open the Trig command list, and select TLIN.
   (↱)(TRIG)(▲)(▲)(▲)(▲)(▲)(▲)(ENTER)




2. With the cursor positioned between the parentheses, open Equation Writer and create the expression. Then press (ENTER) to place it on the command line between the parentheses.
   (EQW) … (ENTER)

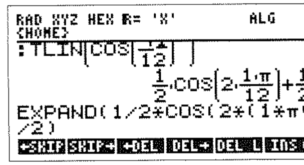



3. Press (ENTER) to simplify the expression.
   (ENTER)

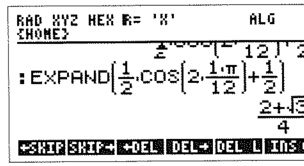



4. Open the Algebra command list, and select EXPAND.
   (↱)(ALG)(ENTER)

5. Retrieve the result of step 3 from history.
   (HIST) (ENTER)




6. Press (ENTER) to expand the expression.
   (ENTER)




## Calculus commands

Use the following commands from the Calculus choose list to differentiate and integrate expressions.

DERVX — Calculus command list—(←) (CALC) DERIV. & INTEG

Differentiates an expression with respect to the default independent variable. The default independent variable is X.

DERIV — Calculus command list—(←) (CALC) DERIV. & INTEG

Differentiates an expression with respect to the variable you specify as a parameter after the expression.

INTVX — Calculus command list—(←) (CALC) DERIV. & INTEG

Integrates an expression with respect to the default independent variable.

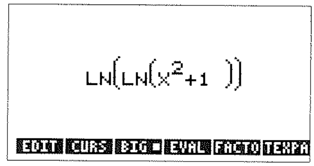
RISCH — Calculus command list—(←) (CALC) DERIV. & INTEG

Integrates an expression with respect to the variable you specify as a parameter after the expression.

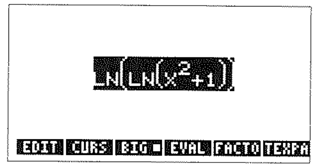
## Example

This example illustrates how to use the DERVX command to differentiate an expression and to use the EXPAND command to simplify the result.

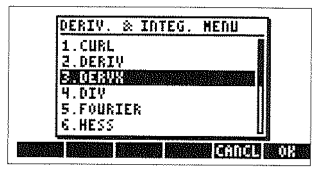
1. Open Equation Writer and create the expression.
   [EQW] [↱] [LN] [↱] [LN] [$x$] [$y^x$] 2 [▶] [+] 1



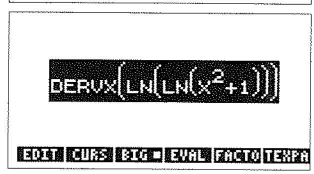

2. Select the expression.
   [▲] [▲] [▲] [▲]



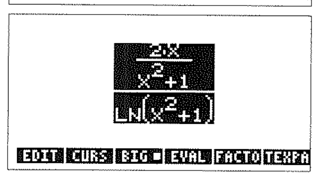

3. Open the Calculus command list, select DERIV & INTEG and highlight the DERVX command.
   [↰] [CALC] [ENTER] [▼] [▼]



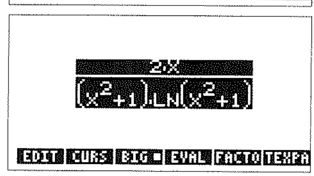

4. Apply the command to the selection. Note that as DERVX is a function, it does not differentiate the expression immediately.
   [ENTER]




5. Differentiate the expression.
   [↱] [EVAL]




6. Use the EXPAND command from the Algebra choose list to simplify the result. Note that, as EXPAND is a command, it expands the expression immediately.
   [↱] [ALG] [ENTER]



# Differentiating an expression step-by-step

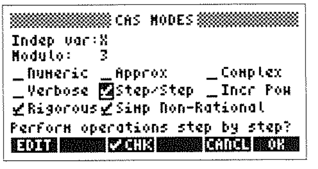


You can use the HP 49G to differentiate expressions in step-by-step mode. The computer algebra system displays the results of each stage of the differentiation process. The results of each step of the operation are written to History.

## Setting step-by-step mode

You use the CAS Modes input form to set step-by-step mode.

1. Press (MODE).
   The Calculator Modes input form is displayed.
2. Press CAS.
   The CAS Modes input form is displayed.
3. Press (▼)(▼)(▼) to move the cursor to the Step/Step field and press CHK.
   A check mark appears next to the mode setting.
4. Press (ENTER) twice to return to the default screen.




## Performing step-by-step operations

You can perform step-by-step operations from within Equation Writer.

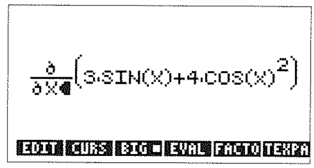
1. Use the above method to set step-by-step mode.
2. Access Equation Writer and either create or import the expression that you want to work on.
3. Use the arrow keys to select the expression.
4. Press (EVAL) to perform the first step in the operation.
   The result of the first step is displayed.
5. Press (EVAL) to perform the next step in the operation. Each time you press (EVAL), the calculator performs the next step in the process, and displays the result.

## Step-by-step example

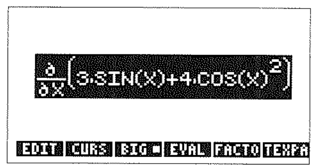
This example differentiates the following expression in step-by-step mode.

$$3\sin x + 4\cos^2 x$$

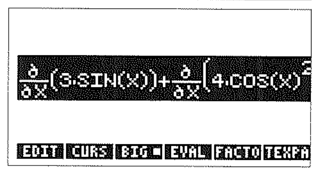
1. Use the method described in the previous section to ensure that step-by-step mode is set.
2. Press [EQW] to open Equation Writer.
3. Create the expression
   3[SIN][x][▶][▶][+]4[COS][x][▶][$y^x$]2[▶][▶][▶][↱]
   [∂][x]



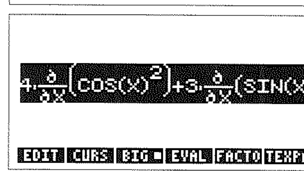

4. Select the expression.
   [▲][▲]



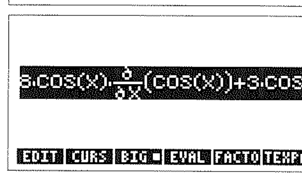

5. Evaluate the first step.
   [↱][EVAL]



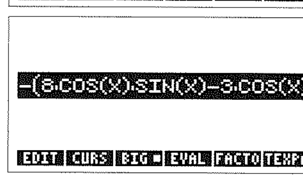

6. Evaluate the next step.
   [↱][EVAL]




7. Evaluate the next step.
   [↱][EVAL]




8. Evaluate the last step. This returns the final result of the derivation.
   [↱][EVAL]



# Chapter 6

# Solving equations

## Contents



## Introduction

This chapter describes how to use the HP 49G to solve equations, or systems of equations, to get a numeric solution. To solve equations for symbolic solutions, see chapter 5, "Working with expressions."

This chapter also includes information on how to use the financial solver to calculate details on amounts of money borrowed or lent.

# About solving equations

You can use the HP 49G numeric solver to solve four types of equations. You select the type of equation that you want to solve from the numeric solver choose list.

To access the numeric solver choose list, press ⬏ NUM.SLV.

The following options are available from the choose list:

- Solve equation

  Use this option to solve an equation for an unknown variable. For example, you can use the this option to solve the following equation for $x$:

$$4\sin(x) + 5\cos(x)\ln(x^2 + 3) = 0$$

- Solve polynomial equation

  Use this option to find the roots of a polynomial equation. For example, you can use this option to find the roots of the following polynomial:

$$5x^3 + 4x^2 - 3x + 2$$

- Solve linear systems

  Use this option to solve a system of linear equations, that is, a set of simultaneous equations. For example, you can use this option to solve the following simultaneous equations to find the value of $x$ and $y$.

$$3x + 2y = 5$$
$$2x - 8y = 7$$

- Solve differential equation

  Use this option to solve first order differential equations, that is an equation that contains a derivative. For example, the following first-order differential equation describes the rate of radioactive decay:

$$\frac{dN}{dT} = -KN$$

# Solving an equation

In solving an equation, the HP 49G uses any existing values it has stored for the variables in the equation. These may be variables that you have created, or variables that the calculator has used in, or generated from, previous calculations. Before you solve an equation, if necessary use File Manager to delete any variables corresponding to the ones that your equation contains.

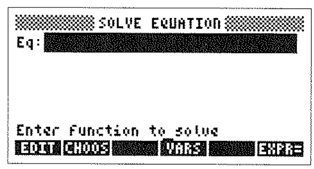
## Example

This example demonstrates how to solve an equation in $x$ and $y$ for $x$, when $y = 2$. The equation is:

$$4\cos\left(\frac{x}{y}\right) + 3\sin(\pi x) = \sqrt{2}$$

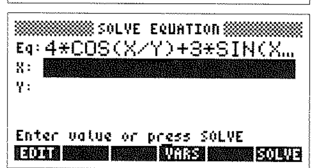
1. Open the numeric solver choose list and select SOLVE EQUATION from the menu. The Solve Equation input form is displayed.

   ↱ NUM.SLV ENTER



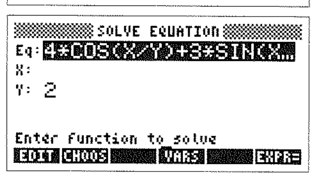

2. Enter the equation to solve and place it in the EQ field.

   4 × COS $x$ ÷ ALPHA Y ▶ + 3 × SIN
   ↰ π × $x$ ▶ ↱ = √x 2 ENTER



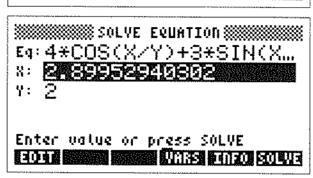

3. The variables that the equation contains are displayed. Enter the known value for $y$ in the Y: field.

   ▼ ▼ 2 OK




4. Select the X: field and press SOLVE to solve the equation for $x$. The solution appears in the X: field.

   ▲ SOLVE




To speed up the solve process, enter an estimate of the value for the variable that you want to find.

## Interpreting results

After it solves an equation, the numeric solver returns information relating to the solution process.

To display the solution information, press INFO. If the numeric solver found a solution to the equation, it displays one of the following three messages:

| | |
|---|---|
| Zero | The numeric solver was able to solve the equation within the limits of its accuracy. |
| Sign Reversal | The numeric solver found two points where the value of the equation has opposite signs, but it cannot find a point in between where the value is 0. Possible causes are that the two points are less than one in the 12th decimal place apart, or the equation is not real-valued between the sign reversal points. |
| Extremum | This represents one of the following conditions: <br>• The numeric solver found a point where the value of the equation approximates a local minimum or maximum. The point may or may not represent a root. <br>• The numeric solver stopped searching at either the largest or smallest number in the calculator's range. |

If the numeric solver did not find a solution, it displays one of the following explanatory messages:

| | |
|---|---|
| Bad Guess(es) | One or more of the initial guesses lie outside the domain of the equation. |
| Constant? | The value of the equation is the same at every point that was sampled. |

Solving equations

# Solving polynomial equations

Polynomial equations are of the form:

$$ax^n + bx^{n-1} + \ldots + cx^2 + dx + e = 0$$

For example, the following equation is a third order polynomial:

$$5x^3 + 4x^2 - 3x + 2 = 0$$

You can use the HP 49G to:

- find the roots of a polynomial
- find the coefficients of a polynomial, given a set of roots.

To solve a polynomial, you express it as a vector of its coefficients. For example, consider the previous example:

$$5x^3 + 4x^2 - 3x + 2 = 0$$

In vector form, this can be expressed as follows:

$$\begin{bmatrix} 5 & 4 & -3 & 2 \end{bmatrix}$$

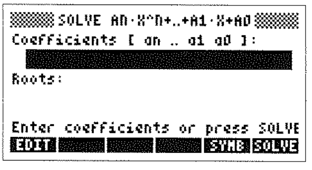
Note that if a polynomial does not include a term for a particular power, you need to include a 0 in the vector to represent the term. For example:

| **Equation** | **Vector** |
|---|---|
| $3x^2 + 5$ | $\begin{bmatrix} 3 & 0 & 5 \end{bmatrix}$ |
| $5x^3 - 2x$ | $\begin{bmatrix} 5 & 0 & -2 & 0 \end{bmatrix}$ |

## Example

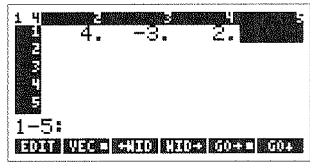
This example describes how to find the roots of the polynomial equation $5x^3 + 4x^2 - 3x + 2 = 0$.

1. Open the numeric solver and select SOLVE POLY to display the Coefficients input form.

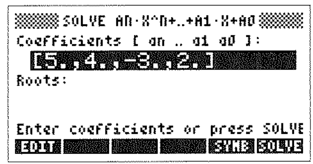


2. With the cursor in the Coefficients field, press EDIT. Matrix Writer opens, ready for use.

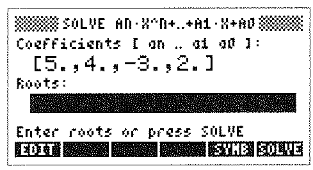
3. In Matrix Writer, enter the coefficients on the top row of the matrix. See chapter 8, “Vectors, lists, arrays, and matrices” for information on using Matrix Writer.



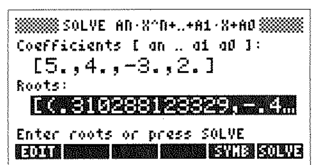

4. Press (ENTER) to place the values on the input form.




5. Press (▼) to place the cursor in the Roots field.

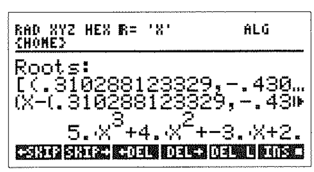



6. Press SOLVE. The HP 49G solves the equation and places the roots, in vector form, in the Roots field.




7. To copy the equation or the roots to the command line, move to the field to copy and press SYMB.

SYMB(▲)SYMB(ENTER)



## Finding a polynomial from a set of roots

To find a polynomial equation that corresponds to a set of roots, use the following procedure:

1. Open the numeric solver and select SOLVE POLY to display the Coefficients input form.
2. Press ▼ to place the cursor in the Roots field, and press EDIT. Matrix Writer opens, ready for use.
3. In Matrix Writer, enter the roots on the top row of the matrix, and press ENTER to place the values, in vector form, on the input form.
4. Press ▲ to place the cursor in the Coefficients field.
5. Press SOLVE. The numeric solver solves the equation and places the coefficients, in vector form, in the Coefficients field.

# Solving linear systems

A linear system is a set of linear equations where there is more than one independent variable. For example, the following is a system where there are two linear equations and two independent variables.

$$\begin{aligned} 3x + 2y &= 5 \\ 2x - 8y &= 7 \end{aligned}$$

There are three types of linear systems:

- **Exactly determined systems** are systems where there is the same number of equations as there are independent variables. The HP 49G can solve these systems to the limits of its accuracy.
- **Over-determined systems** are systems where there is a greater number of equations than there are independent variables. Usually there is no exact solution to these systems. The HP 49G returns the least-squares solution.
- **Under-determined systems** are systems where there is a smaller number of equations than the number of independent variables. Usually there is an infinite number of solutions to these systems. The HP 49G returns the solution with the minimum Euclidean norm.

## Representing a system as matrices

To solve a linear system, you represent the system in matrix form within the numeric solver. In order to represent the system in matrix form, you need to transpose the equations to a form where the independent variables are to the left of the = sign, and the constant is on the right. For example, consider the following set of equations:

$$\begin{aligned} 2x - 8y + 7 &= 2 \\ 3x + 2y - 1 &= 14 \end{aligned}$$

Before you attempt to solve this system, manipulate the equations to the following form:

$$\begin{aligned} 2x - 8y &= -5 \\ 3x + 2y &= 15 \end{aligned}$$

Solving equations

These equations can be represented as a set of three matrices:

- a matrix that contains the variable coefficients

$$\begin{bmatrix} 2 & -8 \\ 3 & 2 \end{bmatrix}$$

- a matrix that contains the constants

$$\begin{bmatrix} -5 \\ 15 \end{bmatrix}$$

- a matrix that contains the variables to solve for.

$$\begin{bmatrix} x \\ y \end{bmatrix}$$

When you solve this system, you specify the first two matrices and the answers are returned in the third matrix.

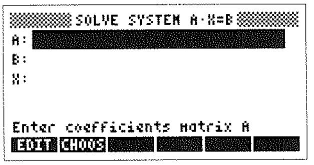
## Example

To solve the following linear system:

$$\begin{aligned} 2x - 8y + 3z &= -5 \\ x - 4y + 2z &= 3 \\ 3x - y - 5z &= 4 \end{aligned}$$

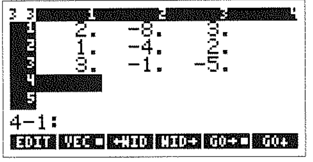
1. Open the numeric solver and select SOLVE LIN SYS to display the Solve System input form.

   (↱)(NUM.SLV)4(ENTER)



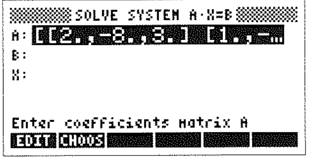

2. Make sure that the cursor is in the A: field and press EDIT. Matrix Writer opens, ready for use. Create a coefficients matrix.

   EDIT ...



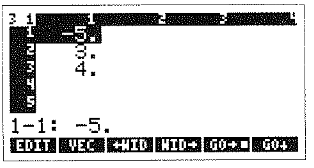

3. Press (ENTER) to return to the Solve System input form. The matrix that you created appears in the A: field.

   (ENTER)



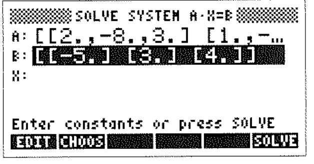

4. Place the cursor in the B: field and press EDIT to display Matrix Writer. Create a constants matrix.

   (▼)EDIT ...



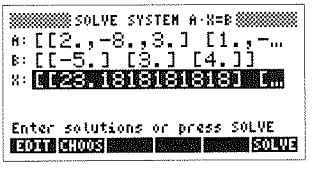

5. Press (ENTER) to return to the Solve System input form. The matrix that you created appears in the B: field.

   (ENTER)

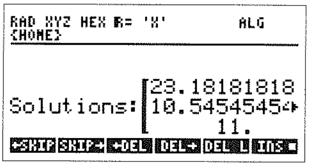



6. Press (▼) to place the cursor in the X: field and press SOLVE. The numeric solver solves the linear system and writes the answers to a matrix. The results matrix is displayed in the X: field.

   (▼) SOLVE



7. Return to the default screen. The results matrix is written to the history.
   (ENTER)




# Solving differential equations

This section explains how to use the numeric solver to solve differential equations.

1. Open the numeric solver and select SOLVE DIFF EQ to display the Solve Equation input form.
2. Use the method described in “Solving an equation” on page 6-3 to specify the equation.
3. Use the arrow keys to navigate to the fields and press EDIT. The default settings are for an equation where $x$ is a function of $y$. The fields are as follows:

| | |
|---|---|
| F: | Holds the equation to be solved. |
| INDEP: | Specifies the independent variable. This defaults to $x$. |
| INIT: | Contains the initial value of the independent variable. |
| FINAL: | Contains the independent variable’s final value. |
| SOLN: | Specifies the solution variable. This defaults to $y$. |
| INIT: | Contains the solution variable’s initial value. |
| FINAL: | Displays the solution variable’s final value when the equation is solved. You cannot edit this value. |
| TOL: | Contains the acceptable level of absolute error. This defaults to 0.0001. |
| STEP: | Contains the initial step size to be used as the solver attempts to find a solution. |
| STIFF | Check this field when the solve process does not work, or is taking a long time. It displays additional fields where you can enter partial derivative information in order to obtain a stiff solution. See the *Advanced User’s Guide* for more information. |

4. Press SOLVE. The calculator solves the equation. If the process takes a long time, or does not produce a solution:
   a. Press CANCEL to stop the process.
   b. Re-edit the input form to check the STIFF option.
   c. Enter partial derivative information before trying again.

# Using the financial solver

Use the financial solver to perform time-value-of-money calculations, and to calculate amortization amounts that relate to these calculations.

- Time-value-of-money calculations relate to a borrowed amount of money that is to be repaid, at a fixed compounding interest rate, over a period of time.
- Amortization is the way the repayments are divided between the principal amount and interest on the loan.

The financial solver allows you to calculate any one of the parameters for a time-value-of-money transaction. You can perform modelling by entering all parameters except one, and calculating the value for the missing one.

## Time-value-of-money calculation parameters

The financial solver uses the following parameters:

| | |
|---|---|
| N | The total number of compounding interest periods and payments. A compounding interest period is the period after which the amount of interest that the loan has accrued is added to the principal. The financial solver assumes that this period corresponds to the payment period. |
| I%YR | The annual interest rate, expressed as a nominal percentage. |
| PV | The value of the loan at the beginning of the first period. |
| PMT | The periodic payment amount, or the repayment amount that is to be made in each period. |
| FV | The value of the loan at the end of the $N^{th}$ period. For example, if you were calculating details of a complete loan repayment, this value would be 0. |
| BEG/END | Whether the payment is made at the beginning or end of the payment period. |

## Time-value-of-money calculations

1. Press ⬑ FINANCE to open the financial solver.

   The Time Value of Money input form is displayed.

2. Depending on the value that you want to calculate, enter values into the fields.
   - To enter a value in a field, place the cursor in the field, enter the value and press ENTER. The value appears in the highlighted field.
   - To edit an existing value, place the cursor in the field and press EDIT. Edit the value on the command line and press ENTER.
   - To specify whether payments are made at the beginning or the end of the payment period, place the highlight in the Beg/End field and press CHOOS. (The Beg/End field is immediately below the P/Yr field. It displays either BEG or END.) Select the value you want from the list.

3. Use the arrow keys to move the cursor to the field for the value to be determined and press SOLVE.

   The financial solver solves the calculation and the computed value appears in the field.

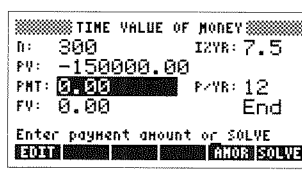
4. Press CANCEL to return to the default screen. The value that you computed is displayed in the history.

For example, to calculate the monthly payments on a $150,000 mortgage over a 25 year period at an interest rate of 7.5%:

1. Press ⬑ FINANCE to open the financial solver.

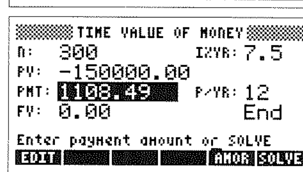
   The Time Value of Money input form is displayed.

2. Enter the values into the relevant fields. Note that the number of payments is 300, or 25 times 12.




3. Use the arrow keys to place the cursor in the PMT field, and press SOLVE. The monthly amount appears in the PMT field.

   SOLVE



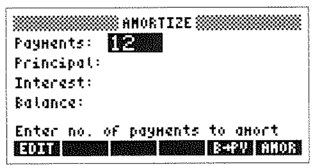
## Amortizing the calculation

After you have performed a time-value-of-money calculation, you can amortize the results, that is, calculate the amount of principal and the amount of interest that you pay over a period.

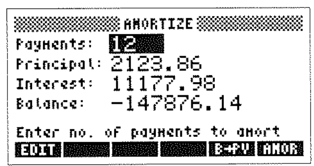
The starting value for the amortization calculations, that is the point from which the payment and interest details is calculated, is the initial value (stored in the PV field) in the Time Value of Money input form. To amortize payments from the previous example, perform the following:

1. Enter details for the time-value-of-money calculation, and find the monthly payment value as in the previous example.
2. Press AMOR. The Amortize input form is displayed.

   AMOR




3. In the Payments field, ensure that the number of payments to amortize is set to 12, and press AMOR. The financial solver amortizes the payments and displays the results.




   AMOR

   For the first year's payments, the financial solver tells you:

   - the principal remaining after the number of payments is made
   - the interest component of the payments
   - the balance of the principal after the number of payments have been made.

Once you have amortized a batch of payments, you can set the loan balance as the starting value for amortization. This way you can amortize payments for each year to compare principal and interest details at different stages of the loan.

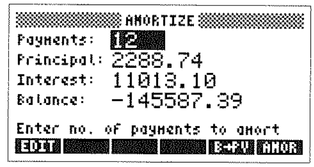
To amortize the second year of the loan's payments:

1. Press B→PV.

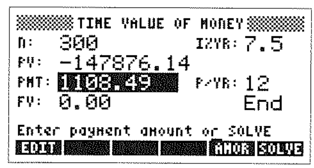
   The starting value is set to the value in the Balance field.

2. In the Payments field, ensure that the number of payments to amortize is set to 12, and press AMOR. The financial solver amortizes the second year's payments, and displays the details.

   AMOR




3. When you finish, press CANCEL to return to the Time Value of Money input form. Note that the current starting amount is displayed in the PV field.



# Chapter 7

# Storing objects

## Contents



## Introduction

You store an object by giving it a name and saving it. An object saved in this way is called a *variable.* Any object you create—numbers, equations, programs, graphics, and so on—can be stored in a variable.

You can create directories and subdirectories to store your variables, or you can store variables in the default directory (called *HOME).*

There are four areas within the HP 49G for storing variables: the HOME directory (and the subdirectories it contains), port 0, port 1, and port 2. By moving objects you want to keep to port memory, you make more user memory available for everyday operations.

# Variables

Variables enable you to store and retrieve objects. You do this by giving an object a name. For example, if you regularly use a particular number in calculations—say, 9.81 m/s², the acceleration of gravity—you can create a variable that associates this number with a name.

Variable names can be up to 127 characters long and can contain letters, digits, and most other characters. You could, for example, call 9.81 m/s² *G*, *G1*, *or GRAV.* Then when you need to use 9.81 m/s² in a calculation, you can enter the variable name, or select it from a menu.

Some characters cannot be included in a variable name. These are:

- characters that separate objects: space, period, comma, @
- object delimiters: # [ ] " ' { } ( ) : _ «»
- mathematical symbols; for example, + – * / ^ + < > ! √ = ≤ ≥ ≠ ∂ ∫.

Also, you cannot use a command name or a menu name as the name of a variable.

You can store any type of object in a variable: numbers, character strings, equations, programs, graphics, and so on.

## Creating a variable

1. Enter the data that you want to associate with a variable.
2. Press (STO▸) to select the STORE command.
3. Enter a name for the variable. (See chapter 2, "Basic operation", for information on how to enter alphabetic characters.)
4. Press (ENTER) to create the variable.

For example, to create a variable named GRAV to store the value 9.81, enter the following on the command line:

9.81 (STO▸) (ALPHA) (ALPHA) GRAV (ENTER)

See "Creating a directory" on page 7-6 for details of another method of creating variables.

Storing objects

## Listing variables

There are two ways to see the variables you have created:

- press (VAR)
- press (⬅)(FILES). This opens the file management tool called *File Manager* and displays the directory tree. The directory tree is an expandable list of ports and directories on your HP 49G.

### Using (VAR)

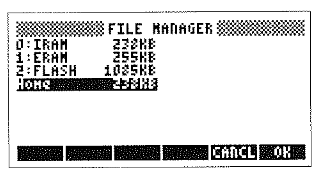
When you press (VAR), the names of the variables appear on the function-key menu. If you have created more than 6 variables, press (NXT) to display the next set of 6 variables.

Note that only the first 5 characters of a variable's name appear on the (VAR) menu. To see the full name of a variable, press the function key—(F1) to (F6)—that corresponds to the variable. The full name of the variable is displayed on the command line. To see what data is stored in that variable, press (ENTER).

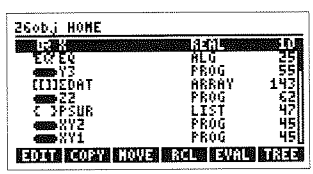
The variables listed by pressing (VAR) are the variables stored in the current directory. To see the variables stored in another directory, you must first select that directory. (See "Directories" on page 7-5 for more information.)

### Using File Manager

When you open File Manager, only the ports and the HOME directory are listed. To see the variables in a directory, you need to select that directory. This is explained on page 7-8.




When you select a directory, all objects in that directory—variables and sub-directories—are listed. (You also see the type of each object and its size.) To see the variables and other objects in a sub-directory, select the sub-directory.



## Using a variable in a calculation

You can use a variable's contents in a calculation. To continue the example on page 7-2, suppose you have stored the acceleration of gravity in a variable named GRAV and that this variable happens to be represented by (F3). To multiply the acceleration of gravity by 7, you would press:

(VAR)(F3)(X)7(ENTER)

(VAR) (F3) places the variable's name on the command line. Pressing (ENTER) causes the variable, and then the entire expression, to be evaluated.

Note that if the variable you want to use is not available when you press (VAR), you must first select the directory in which the variable is stored. (See "Selecting a directory or variable" on page 7-7.)

## User-defined functions

User-defined functions are a special type of variable. Like variables, you give a user-defined function a name, and store it for later use.

User-defined functions operate in the same way as normal functions: that is, you enter the function name, specify the argument or arguments in parentheses, and then press (ENTER) or (⤴)(→NUM) to evaluate the function. The difference is that you create the function yourself, and give it a name of your choosing.

### Creating a user-defined function

The following example illustrates how to create a user-defined function to evaluate $3\cos(x^2)$ and store it with the name "F2($x$)":

1. Press (⤶)(DEF) to place the DEFINE command on the command line.
2. With the cursor between the command's parentheses, define the function.

   (ALPHA)F2(⤶)(( ))($x$)(▶)(⤴)(=)3(COS)($x$)($y^x$)2

   Note that the name you want to give your function must appear to the left of the equals sign. You specify the function to the right of the equals sign.
3. Press (ENTER) to define the function and store it in the current directory. In this example, it is stored as "F2".

### Evaluating a user-defined function

To evaluate a user-defined function:

1. Go to the directory where you stored the function, and press VAR.

   The variables in the directory are displayed on the function-key menu.
2. Press the function key that corresponds to the variable.

   The function name is displayed on the command line.
3. With the cursor after the function name, press ↱ () to insert parentheses.
4. Enter the argument or arguments between the parentheses.

   If the function takes more than one argument, separate each argument with a comma.
5. To evaluate the function:
   - press ENTER to obtain an exact answer, or
   - press ↱ →NUM to obtain an approximate answer.

# Directories

You can create directories on the HP 49G just as you create directories on a computer. A directory is simply a named area of memory in which you can store variables (and other directories).

For example, you might create a number of variables relating to mechanical engineering calculations. You would probably find these variables more easily if they were stored together. Therefore, you could create a directory and store just your mechanical engineering variables in that directory. Then, when you need one of the these variables, you go to that directory and select the variable.

When you turn on the HP 49G for the very first time, you will find just one directory. This is called *HOME*. Unless you specify otherwise, all the variables you create will be stored in HOME. If you intend to create numerous variables, you may find it easier if you create a directory for each set of similar variables you create: one directory for your mechanical engineering variables, another for chemistry variables, and so on.

## Creating a directory

1. Press ⬅ FILES.

   This opens the file management tool called *File Manager* and displays the directory tree.

2. Select the directory that is to be the parent of your new directory. (See “Selecting a directory or variable” on page 7-7.)

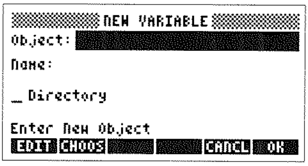
   Note that any directory you create must be a child of another directory (that is, contained within some other directory). The very first directory you create will be a child of HOME.

3. Press OK.

   The screen now lists the variables and subdirectories in the directory selected at step 2. The File Manager function-key menu is also displayed.

4. Press NXT NEW.

   The New Variable input form is displayed.




5. Press ▼ to select the Name field.

   The Object field must be left blank when you are creating a new directory.

6. In the Name field, enter a name for the new directory.

   The naming conventions and restrictions that apply to directory names are the same as those that apply to variable names. See page 7-2 for more information.

   The cursor jumps to the Directory field after you enter the name.

7. Press CHK to indicate that you are creating a directory.

8. Press OK or ENTER.

   The list of variables and subdirectories displayed at step 3 above now includes the directory you just created.

9. To return to the default display, press CANCEL.

You can also create a variable using the above procedure. With the cursor in the Object field, you either enter an object’s contents, or press CHOOS to select an existing object for editing (the contents appear in the Object field). You specify a name for the variable in the Name field, and leave the Directory field unchecked.

# Selecting a directory or variable

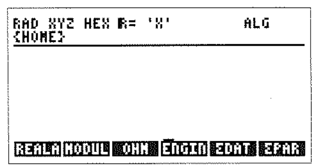
Your current directory—also known as your path—is shown at the start of the second line of the status area. To work with another directory, you need to select that directory. You must do this, for example, if you want to use a variable stored in that directory.

The methods described below for selecting a directory are the same methods you use to select a variable within a directory.

## Method 1

Use this method if the directory you want to select is below—but not too far below—the current directory in the directory tree.

1. Press (VAR).

   A menu of the variables and subdirectories in the current directory is displayed. Subdirectories can be distinguished from variables by a small bar across the top left-hand corner of the menu item. The example at the right shows that the HOME directory contains a subdirectory called ENGIN and a number of variables: REALA, MODUL, OHM, and so on.

   Whenever you press (VAR), the variables and subdirectories displayed are just those contained in the directory whose name is shown in the status area. Also, whenever you create a new variable or subdirectory, that variable or subdirectory is placed in the directory whose name is shown in the status area.

2. Select a directory by pressing the corresponding function key and then pressing (ENTER).

   In the above example, you press (F4) and (ENTER) to select the ENGIN subdirectory.

   If there are more than 6 variables and subdirectories in your current directory, you may need to press (NXT) before the name of the subdirectory you want to select appears on the screen.

The variables and directories now shown on the menu are those contained in the subdirectory you chose. If the subdirectory you want to finally work with is further down the directory tree, you will need to repeat step 2 until its name is displayed on the menu.

### Method 2

Use this method when the directory you want to select is on a different branch of the directory tree or is many levels above or below your current directory.

1. Press ⬅ FILES

   The directory tree is displayed showing, for each directory, its parent directory and its subdirectories (if any). Your current directory is highlighted.
2. Press ▲ or ▼ until the directory you want to select is highlighted.
3. Press ▶.
4. Press NXT NXT F1 HALT.

   The default display returns and your new path is the directory you chose from the directory tree.

### Method 3

If the directory you want to select is above, and on the same branch as, your current directory, you can press ⬅ UPDIR ENTER until the directory you want becomes the current directory.

# Managing variables and directories

The HP 49G provides many tools to help you manage your variables and directories. For example, you can delete, copy, move, and rename variables and directories. You can also edit a variable's data.

## Deleting a variable or directory

The variables in a directory are deleted when you delete the directory. However, you cannot delete a directory if it contains another directory.

1. Use File Manager (⬅ FILES) to select the parent directory of the variable or directory you want to delete. (See "Selecting a directory or variable" on page 7-7.) A list of all the objects in that directory is displayed.
2. Highlight the name of the variable or directory you want to delete.
3. Press NXT F1 to select PURGE.

   A message is displayed asking you to confirm that you want to delete the variable or directory you selected.
4. Press F1 to delete the variable or directory.
5. Press CANCEL to return to the default display.

## Copying or moving a variable or directory

1. Use File Manager (⬅ FILES) to select the parent directory of the variable or directory you want to copy or move. (See "Selecting a directory or variable" on page 7-7.) A list of all the objects in that directory is displayed.
2. Highlight the name of the variable or directory you want to copy or move.
3. To copy your selection, press COPY, to move your selection, press MOVE. The directory tree is redisplayed.
4. Press ▲ or ▼ until the *destination* directory is highlighted.

   The destination directory is the directory where you want the variable or directory copied or moved to.
5. Press OK.

   A warning is displayed if the variable or directory you are copying or moving already exists in the destination directory. In this case, either:
   - overwrite the existing variable or directory (by pressing YES or ALL)
   - cancel the operation (by pressing ABORT or NO), or
   - rename the variable or directory you are copying or moving (by pressing REN).

   To check the new directory tree, press TREE.
6. Press CANCEL to return to the default display.

## Renaming a variable or directory

1. Use File Manager (⬅ FILES) to select the parent directory of the variable or directory you want to rename. (See "Selecting a directory or variable" on page 7-7.) A list of all the objects in that directory is displayed.
2. Highlight the name of the variable or directory you want to rename.
3. Press NXT RENAME.

   The present name of the variable or directory is displayed on the command line. Note that the alpha keyboard has become active and you do not need to press ALPHA before changing the name.
4. Change the name of the variable or directory. (See chapter 2 for instructions on how to edit the contents of the command line.)
5. Press ENTER. The contents of the parent directory are redisplayed, showing the new name of the variable or directory.
6. Press CANCEL to return to the default display.

## Editing a variable

Edit a variable when you want to change its contents.

1. Use File Manager (⬅ FILES) to select the directory that contains the variable you want to edit. (See "Selecting a directory or variable" on page 7-7.) A list of all the objects in that directory is displayed.
2. Highlight the name of the variable or directory you want to edit.
3. Press NXT NXT EDITB.

   The contents of the variable are now available.

   The EDITB command enables you to edit the contents using an editor that is appropriate to the type of object stored in the variable. For example, if the variable is storing a matrix, EDITB displays the matrix in Matrix Writer. If it is storing an equation, it displays the equation in Equation Writer, and so on).
4. Change the contents of the variable.
5. Press ENTER.
6. Press CANCEL to return to the default display.

# Memory Management

The HP 49G has 512 Kb of RAM and 2 Mb of Flash ROM.

RAM is segmented into system memory, user memory, port 0 and port 1.

System memory stores system variables. You do not have access to system memory.

User memory contains the HOME directory (and its subdirectories), history, working memory (that is, memory available for use by calculations and executing programs) and a number of temporary variables created either by the system or by executing programs.

Port 0 is available for storing libraries and for backed-up objects, and port 1 can be used to store objects.

Flash ROM is segmented into system memory—which is an extension of RAM system memory—and port 2. Like port 1, port 2 can be used to store objects you create or download.

Objects stored in port memory can be called or executed, but they cannot be viewed or edited unless copied to main memory.

*In total, the HP 49G offers over 1 Mb of port memory.*

## Using port memory

Objects that you want to keep should be moved from user memory to port memory. This not only makes more user memory available for everyday operations, but it puts objects you want to keep into a safer storage environment. (Ports 0 and 1 are safer than user memory, and port 2 is safer than ports 0 and 1.)

### Moving objects to port memory

You move objects to port memory in the same way that you move objects from HOME directory to subdirectories of HOME (or between subdirectories). To view or edit an object in port memory, you must first copy or move it to user memory.

To move an object to a port:

1. Use File Manager to select the object you want to move. (Follow the steps in "Selecting a directory or variable" on page 7-7.)
2. Press MOVE.

   The directory tree is redisplayed.
3. Press ▲ or ▼ until the destination port is highlighted.

   The destination port is the port where you want to store the object.
4. Press OK.

   A warning is displayed if an object of the same name already exists in the destination port. In this case, either:
   - overwrite the existing object (by pressing YES or ALL)
   - cancel the operation (by pressing ABORT or NO), or
   - rename the object you are moving (by pressing REN).
5. Press CANCEL to return to the default display.

Storing objects

# Chapter 8

# Vectors, lists, arrays, and matrices

## Contents



## Introduction

The HP 49G provides numerous tools for creating, manipulating, and analyzing vectors, lists, arrays, and matrices. Vectors of any dimension can be created, commands can be made to operate over multiple elements in a list, and matrices can be used to specify statistical data and to solve systems of linear equations.

# Vectors

A vector is a way of representing quantities that are measured both by magnitude and by direction. An example is velocity.

Most often you will work with 2- and 3-dimensional vectors, although vectors of any dimension are possible. The HP 49G enables you to specify, and work with, vectors of any dimension.

A 2-dimensional vector can be described in rectangular notation [$x$, $y$]—or in polar notation—[$r$; θ]. For 3-dimensional vectors, you can use rectangular notation—[$x$, $y$, $z$]— cylindrical notation—[$r$, θ, $z$]—or spherical notation—[$r$, θ, ϕ]. All these notations are available with the HP 49G.

## Creating vectors

You should first decide on the notation you want to use.

### Selecting vector notation

The currently set notation is indicated by the coordinates annunciator: XYZ indicates rectangular notation, R∠Z indicates cylindrical notation, and R∠∠ indicates spherical notation. You need to choose a new notation if the currently set notation is not the one you want to use. (Note: you must choose *polar* notation if you are creating a 3-D cylindrical vector.)

1. Press MODE to display the Calculator Modes input form.
2. Set the Coordinate System field to the notation that you want. (See page 2-11 for information on changing the fields on an input form.)
3. Press OK to set the notation you chose.

### Selecting an angle unit

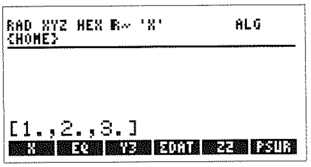
The currently set angle unit is indicated by the angle annunciator: DEG indicates degrees, RAD indicates radians—the default setting—and GRD indicates gradians. If you intend to use a vector notation that requires an angle measurement and the current angle unit is not what you want, reset the unit before entering your vector. See "Changing a mode" on page 2-18 for instructions on resetting the angle unit.

### Entering vectors

You enter a vector by specifying its components between square brackets:

1. Press ⬅ [ ]
2. Enter the first component.

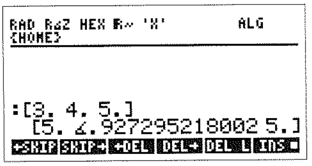
   If you are entering a real vector rather than a symbolic vector, immediately follow each component with a decimal point (as in the example below).
3. Enter each subsequent component. Separate rectangular components with a comma but precede an angular component with the angle sign: ∡. (The angle sign can be entered by pressing (ALPHA) ➦ 6.)




4. Press (ENTER).

You can also enter a vector by creating a single-row matrix with Matrix Writer. This is explained later in this chapter.

If the coordinates notation does not match your entry, the HP 49G converts your entry to that notation. In the example at the right, the second argument—4.—is converted to an angle measurement because the coordinates notation is set to polar (indicated by the polar annunciator). Note that symbolic vectors—including those with integer elements—are not converted to the angle measurements.




## Vector mathematics

Two vectors can be added and subtracted on the HP 49G just as real numbers are added and subtracted. For instance, to add two vectors, enter the first vector, press (+), enter the second vector and press (ENTER).

You can also multiply and divide a vector by a scalar.

The HP 49G also provides a number of special commands for working with vectors. Three of these commands—absolute magnitude, dot product, and cross product—are described in detail in the next three sections.

## Absolute magnitude

The *absolute magnitude* of a vector—also known as the *scalar magnitude*—is the square root of the sum of the squares of the value of each element.

To calculate the absolute magnitude of [1 2 4]:

1. Press [↰][ABS].
2. Press [↰][[ ]].
3. Enter 1 [↱][,] 2 [↱][,] 4
4. Press [ENTER].

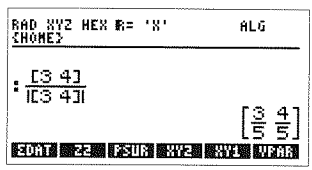
The result is $\sqrt{21}$.

An example where you need to calculate the absolute magnitude is in finding the unit vector. The unit vector is found by dividing the given vector by its magnitude:

$$\mathbf{u} = \frac{\mathbf{v}}{|\mathbf{v}|}$$

Suppose you want to find the unit vector of [3 4]:

1. Press [↰] [[ ]] 3 [↱][,] 4 [▶] to enter the numerator.
2. Press [÷].
3. Press [↰][ABS].
4. Press [↰][[ ]] 3 [↱][,] 4 to complete the denominator.
5. Press [ENTER] to obtain the unit vector, which in this case is: $\left[\frac{3}{5}, \frac{4}{5}\right]$

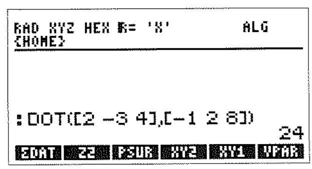


## Dot product

The *dot product* of two vectors of equal dimensions is the sum of the products of each corresponding pair of elements. The dot product is also known as the *inner* or *scalar product.*

To find the dot product of [2 –3 4] and [–1 2 8]:

1. Press ↰ MTH to select the MATH menu.
2. Press OK or ENTER to select the VECTOR menu.
3. Press ▼ to highlight the DOT command and press OK or ENTER.
4. Press ↰ [ ] to enter a pair of square brackets to enclose the first vector.
5. Enter 2 ↱ , 3 +/- ↱ , 4.
6. Press ▶ to move your cursor outside the square brackets, thereby indicating that the first vector is complete.
7. Press ↱ , to indicate the end of the first argument.
8. Press ↰ [ ] to enter a pair of square brackets to enclose your second vector.
9. Enter 1 +/- ↱ , 2 ↱ , 8.
10. Press ENTER to return the dot product of the two vectors, in this case, 24.

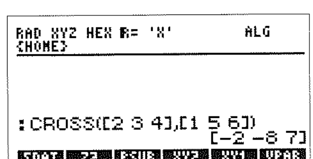



## Cross product

For two vectors [*a b c*] and [*d e f*], the cross product is [*(bf – ce) (cd – af) (ae – bd)*]. The cross product of two vectors is also known as the *vector product* or *outer product.*

To find the cross product of [2 3 4] and [1 5 6]:

1. Press ↰ MTH to select the MATH menu.
2. Press OK or ENTER to select the VECTOR menu.
3. Press ▼ twice to highlight the CROSS command and press OK or ENTER.
4. Enter the two vectors, separating them with a comma.
5. Press ENTER to return the cross product of the two vectors, in this case, [–2 –8 7].



# Lists

A list is a collection of any number of objects. The objects can be of any type—numbers, character strings, and so on—and objects of different types can appear in the one list. A list is represented on the HP 49G by a pair of braces ({}) surrounding a collection of objects.

## Creating a list

1. Press [←] [{}]
   This indicates that you want to create a list.
2. Enter the elements you want to include in the list, separating each with a comma (that is, [→] [,]).
3. Press [ENTER].

## Working with lists

### Single-argument commands

Commands that require only one argument can be applied to each element in a list in a single operation.

For example, to find the square root of 5, 6, and 7:

1. Press [√x].
2. Press[←] [{}] 5 [→] [,] 6 [→] [,] 7.
3. Press [ENTER].
   The positive square root of each of the three numbers in the list is returned, with the three results displayed in a list.

### Multiple-argument commands

Commands that require more than one argument can be applied to each element in a list in a single operation.

For example, suppose you want to calculate how many samples of 4 objects can be made from populations of 5, 6, and 7 objects.

1. Press [←] [MTH] to select the MATH menu.
2. Use the arrow keys to highlight the PROBABILITY menu.
3. Press OK or [ENTER].
4. Press OK or [ENTER] to select the COMB command.

5. Press [⬑] [{ }] 5 [⬏] [,] 6 [⬏] [,] 7.
6. Press [▶]

   The cursor is now outside the list of the populations to be sampled.
7. Press [⬏] [,] 4
8. Press [ENTER].

   The answers are returned in a list: {5 15 35}.

Note that the command was applied to two parameters—the list of the various populations, and the size of the sample—each separated by a comma within a pair of braces.



# Arrays and matrices

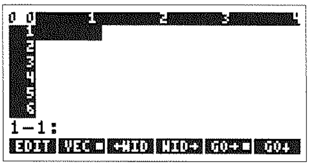
An *array* is any rectangular arrangement of objects. An array of numbers—real or complex—is usually referred to as a *matrix*.

You can create arrays from many types of objects: real numbers, complex numbers, symbolic expressions, character strings, programs and so on. You could, for example, create a database—such as a list of contacts and their telephone numbers—as a type of array.

## Creating arrays

### Using Matrix Writer

You create an array with a special tool called *Matrix Writer*. You open Matrix Writer by pressing [⬑] [MTRW].




When you open the Matrix Writer, the display becomes a table, with the rows and columns numbered like a spreadsheet. The size of the array is indicated by the figures in the top left-hand corner of the table. (The size is 0 × 0 at the start, but this increases as you enter objects into the array.) The row–column coordinates of the currently active cell are shown at the bottom left-hand corner of the display.

To create an array using Matrix Writer:

1. Press [⬑] [MTRW] to open Matrix Writer.
2. Enter the object that is to appear in the first cell of the array.

   This object appears on the command line as you type it.

3. Press (ENTER) to move the object from the command line to the first cell of the array.

   The active cell now becomes 1–2 (that is, the cell at row 1 and column 2).

4. Enter the remaining objects that are to go into row 1 of the array, pressing (ENTER) after each to move it from the command line to the next available cell.

5. When you have typed the last object in the first row of the array, press (▼) to move to the second row of the array and then press (◄) until cell 2–1 becomes the active cell (that is, the first cell in the second row).

6. Enter the objects that are to appear in the second row of your array, pressing (ENTER) after each object.

   Note that the cursor now automatically moves to the first cell of the next row after you enter an object in the last column of a row.

   If you need to add more objects to a row you have already created, use the arrow keys to position your cursor in the appropriate blank cell and enter a new object. See "Quickly moving through an array" below to learn how to quickly move through large arrays.

7. When you have entered all the objects that will comprise your array, press (ENTER).

   Matrix Writer closes and the array you have created appears on the default display screen.

The Matrix Writer function-key menu is explained in detail in the *Pocket Guide* and the *Advanced User's Guide*.

## Using the command line

This method is suitable only for creating small arrays. For large arrays, use Matrix Writer (as described in the previous section).

1. Press (⇦) ([ ]) to enter array delimiters.
2. Press (⇦) ([ ]) to enter row delimiters.
3. Enter the row of elements, pressing (⇨) (,) to separate each element.
4. If you want to enter more rows, continue from step 5 below; otherwise press (ENTER) to create the array.
5. Press (►) to move the cursor to the right of the row delimiter.
6. Repeat from step 2.

## Quickly moving through an array

Key combinations are provided to help you quickly move through an array that is too large to be displayed in full:

(↱) (▶|) moves to the last column.

(↱) (|◀) moves to the first column.

(↱) (▲) moves to the first row.

(↱) (▼) moves to the last row.

(↰) (▶) moves to the next displayable set of columns.

(↰) (◀) moves to the previous displayable set of columns.

(↱) (▲) moves to the previous displayable set of rows.

(↱) (▼) moves to the next displayable set of rows.

## Editing an array

1. Highlight the array in history and press EDIT.

   Matrix Writer opens with your array displayed.

If the array you want to edit is the last object in history, you can also press (▼) to open the array in Matrix Writer.

2. Use the arrow keys to highlight the cell you want to edit.
3. Enter the new value.
4. Press (ENTER) to update the array.
5. If you want to edit other values, repeat from step 3.
6. Press (ENTER) to place the edited array in history.
7. Press (ENTER) again to save the edited array.

## Matrix arithmetic

In matrix arithmetic, you need to enter one or more matrices. You can enter a matrix:

- using Matrix Writer
- by typing it on the command line
- by selecting it from history, or
- by recalling the variable name associated with it.

### Adding or subtracting two matrices

1. Enter the first matrix.
2. Press (+) or (−).
3. Enter the second matrix.

   The second matrix must have the same dimensions as the first.
4. Press (ENTER).

   Each element in the second matrix is added, or subtracted, from the corresponding element in the first matrix.

### Multiplying or dividing a matrix by a scalar

1. Enter the matrix.

   See page 2-4 for information on selecting a matrix from history.
2. Press (X) or (÷).
3. Enter the scalar.
4. Press (ENTER).

   Each element in the matrix is multiplied by, or divided by, the scalar.

## Multiplying two matrices

Since the multiplication of matrices is not commutative, the order in which you specify the matrices is important. The number of columns in the first matrix must equal the number of rows in the second matrix.

1. Enter the first matrix.
2. Press (X).
3. Enter the second matrix.
4. Press (ENTER).

The result is a matrix with the same number of rows as the first matrix and the same number of columns as the second matrix. Each element in the matrix is the product of the corresponding two elements in the original matrices.

## Finding the determinant of a square matrix

1. Enter DET on the command line.
2. Press (←) (( )).
3. Enter the matrix.
4. Press (ENTER).

The determinant of a matrix can be used to solve a system of linear equations. Another method is to use Gaussian elimination to generate the row-reduced echelon form of a matrix. This is discussed in the next section.

## Solving a system of linear equations

A method of solving a system of linear equations is explained in chapter 6. This method uses the numeric solver. The HP 49G also has a matrix command for solving a system of linear equations. This command—RREF—uses Gaussian elimination to generate the row-reduced echelon form of an augmented matrix.

You can use the RREF command in direct mode or in step-by-step mode. (See "Setting step-by-step mode" on page 5-19 for instructions on setting step-by-step mode.) In this mode, the HP 49G performs the Gaussian elimination one step at a time. Before it performs each step, the HP 49G displays a description of the action it is about to perform. You press OK to action each step.

For example, suppose you have to solve the following system:

$$3x + 4y = 25$$

$$5x - 3y = 3$$

Vectors, lists, arrays, matrices

To solve such a system, you can:

1. Enter RREF on the command line.

   "RREF" stands for the ROW-REDUCED ECHELON FORM command.
2. Press ⮌ ( ).
3. Enter or select the augmented matrix.

   The augmented matrix is a matrix of the system's coefficients and constants (with the constants set out in the rightmost column of the matrix). In this example, the augmented matrix looks like this:

$$\begin{bmatrix} 3 & 4 & 25 \\ 5 & -3 & 3 \end{bmatrix}$$

4. Press ENTER.
   - If you are in step-by-step mode, a description of the first step in the process is displayed. Press OK to see the result of that step. Keep pressing OK until you have stepped through the entire reduction process and the row-reduced echelon form of the augmented matrix is displayed.
   - If step-by-step mode is not set, the row-reduced echelon form of the augmented matrix is immediately displayed.

   The row-reduced echelon form of the augmented matrix in our example is:

$$\begin{bmatrix} 1 & 0 & 3 \\ 0 & 1 & 4 \end{bmatrix}$$

The answer to the system of linear equations is in the rightmost column of the row-reduced echelon matrix: in our example, $x = 3$ and $y = 4$.

You can speed up the processing of large matrices by setting the LARGE MATRICES system flag (–110).

# Chapter 9

# Using statistics

## Contents





## Introduction

This chapter describes how to use the HP 49G to analyze data statistically. You can use the HP 49G to analyze two broad categories of statistics:

- **Descriptive statistics** enables you to calculate values such as the mean, the variance, and the standard deviation. You can also apply regression techniques to the data to fit a symbolic model to it.
- **Inferential statistics** enables you to calculate values such as confidence intervals. You can also perform hypothesis tests based on the Normal Z- and Student's t-distributions.

  The inferential statistics applications includes online help. On any of the inferential statistics screens, press HELP to display help on how to complete the screen.

# Descriptive statistics

Use the descriptive statistics applications of the HP 49G to analyze data stored in a matrix.

- Use the **Single-variable statistics** application to calculate values such as the mean, the standard deviation, and the variance for a set of single-variable statistics, for example one column of a matrix.
- Use the **Frequencies** application to determine the frequency distribution for a set of data.
- Use the **Fit data** application to quantify the relationship between the data in two columns.
- Use the **Summary statistics** application to calculate summaries that relate to a set of bivariate data.



## Starting an application and specifying the data

To start a descriptive statistics application:

1. Press ⓡ STAT to display the Statistics choose list.
2. Use the arrow keys to select the statistics application that you want, and press ENTER.

   The input form for the application is displayed.

When you open a statistics application input form, the default data displayed is data that is contained in the ΣDAT variable. From the statistics application input forms, you can do either of the following to specify data to analyze.

- To create new data to analyze, press EDIT to open Matrix Writer. The data you create is stored in the ΣDAT variable.
- To select an object, for example an existing matrix, press CHOOS, and select the object from the list. The data is copied to the ΣDAT variable.

## Single-variable statistics

You specify the column of data within the matrix to analyze.

To calculate single-variable statistics, use the following procedure:

1. Use the method described in "Starting an application and specifying the data" on page 9-2 to open the Single-variable statistics input form and to load the data to analyze.
2. In the Col field, enter the number of the matrix column that holds the data you want to analyze.
3. In the Type field, press CHOOS and select the type of statistical data to measure:
   - Select SAMPLE if your data represents a sample of the population.
   - Select POPULATION if your data represents the entire population.
4. Place the cursor in a field for a statistic that you want to calculate and press CHK. Repeat for other statistics you want to calculate.
5. Press OK. The values you selected are calculated and displayed in a list in history.

The following single-variable statistics can be calculated:

| | |
|---|---|
| Mean | Returns the arithmetic mean. |
| Std Dev | Returns the standard deviation. |
| Variance | Depending on the type that you selected, returns either the sample variance or the population variance. |
| Total | Returns the sum of the data. |
| Maximum | Returns the largest value in the data. |
| Minimum | Returns the smallest value in the data. |

## Generating frequencies

Frequency distributions describe how data is distributed across a specified set of sub-intervals, or bins. You specify:

- the minimum value for data elements to be included in the frequency distribution
- the bin number
- the bin size.

Starting from the minimum value, the statistics application sets up the number of intervals. Each interval is set to the size that you specify. From this, the statistics application defines the maximum value of data to be sampled.

To set up a frequency distribution for your data, use the following procedure:

1. Use the method described in "Starting an application and specifying the data" on page 9-2 to open the Frequencies input form and to load the data to analyze.
2. In the X-Min field, enter the minimum value for samples to be included in the analysis.
3. In the Bin Count field, enter the number of intervals, or bins.
4. In the Bin Width field, enter the size of each interval, or bin.

   The statistics application calculates the highest value to be included in the sample.
5. Press OK. The following data is returned in a list to history:
   - An array of integers, representing the number of data elements that fell into each interval, from lowest interval to highest interval.
   - A two-element vector—the first element represents the number of elements below the lowest value and the second element represents the number of elements above the highest allowable value.

## Fitting a model to a set of data

You can use the statistics application to calculate Pearson's correlation coefficient for bivariate data. The statistics application quantifies the correlation between data in any two columns in a matrix. You can choose a regression model to apply to the data to find the relationship, or you can select the Best Fit option to allow the calculator to find the best correlation from its library of fit types.

The following four regression models are available for selection:

- Linear fit

  $y = b + mx$

- Logarithmic fit

  $y = b + m\ln x$

- Exponential fit

  $y = be^{mx}$ or $\ln y = \ln b + mx$

- Power fit

  $y = bx^{m}$ or $\ln y = \ln b + m\ln x$

To determine details of the regression model that applies to your data, use the following procedure:

1. Use the method described in "Starting an application and specifying the data" on page 9-2 to open the Fit Data input form and to load the data to analyze.
2. In the X-Col field, enter the column number that holds the independent variable values.
3. In the Y-Col field, enter the column number that holds the dependent variable values.
4. Place the cursor in the Model field and press CHOOS. A choose list containing the regression model options is displayed.
5. Select the regression model to apply to the data, or select Best fit to apply the model that best fits the data.
6. Press OK to calculate the regression details. The following items appear in history.
   - Item 1: the covariance value.
   - Item 2: the correlation coefficient.
   - Item 3: the regression formula.

Using statistics

### Predicting a value based on the regression

Once you have performed a regression, you can use it to predict $y$ values.

1. Follow steps 1 to 5 in the previous section to apply a regression to your data.
2. Press PRED. The Predict Values input form is displayed.
3. In the X field, enter the value for which you want to find the corresponding $y$ value.
4. Move the cursor to the Y field and press PRED. The computed value, based on the regression, appears.

Although you can use this method to predict a value for $x$ that corresponds to a known $y$ value, the solution may not be mathematically correct.

## Calculating summary statistics

You can use the summary statistics application to calculate up to six summary statistics on bivariate data.

To calculate summary statistics:

1. Use the method described in “Starting an application and specifying the data” on page 9-2 to open the Summary Statistics input form and to load the data to analyze.
2. In the X-Col and Y-Col fields, specify the columns that hold the data to analyze.
3. Use the arrow keys to navigate around the Calculate fields. Press CHK to choose the values that you want to calculate. A check mark appears against the ones you choose. The summary statistics that can be calculated are as follows:

| | |
|---|---|
| ΣX | The sum of the values in the X-Col of ΣDAT. |
| ΣY | The sum of the values in the Y-Col of ΣDAT. |
| ΣX2 | The sum of the squares of the values in the X-Col of ΣDAT. |
| ΣY2 | The sum of the squares of the values in the Y-Col of ΣDAT. |
| ΣXY | The sum of the products of the X-Col and Y-Col pairs of ΣDAT |
| NΣ | The number of rows in ΣDAT. |

4. Press OK to calculate the statistics. The statistics appear in history.

## Plotting statistics

The following statistical plot types are available:

- Histogram
- Bar
- Scatter

By default, these plot types plot the data stored in ΣDAT. See chapter 4, "Plotting graphs", for details on how to plot statistical data.

# Inferential statistics

The inferential statistics capabilities of the HP 49G include calculation of confidence intervals and hypothesis tests based on the Normal Z-distribution or Student's t-distribution.

Based on the statistics from one or two samples, you can test hypotheses and find confidence intervals for the following quantities:

- mean
- proportion
- difference between two means
- difference between two proportions

The calculator contains online help for each test. You access the online help by pressing HELP on the test input form.

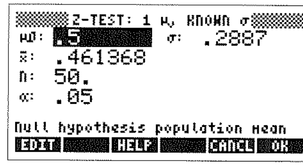
## Example data

When you first access an input form for an inferential statistics test, by default the input form contains example data. This example data is designed to return meaningful results that relate to the test. It is useful for gaining an understanding of what the test does, and for demonstrating the test. The calculator's online help provides a description of what the example data represents.

## Using inferential statistics

To use the inferential statistics functions:

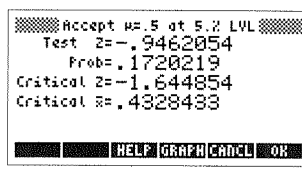
1. Press ⬏ STAT to access the Statistics menu.
2. Select the type of inferential statistics that you want.
   - Select HYPOTH. TESTS to display the hypothesis tests.
   - Select CONF. INTERVAL to display the confidence interval options.
3. From the list, select the hypothesis test or the confidence interval that you want. The input form, containing example data, is displayed. For example, when you select the Z-Test: 1 μ hypothesis test, the input form at the right appears.




   For information on the test or confidence interval, and the example data, press HELP.

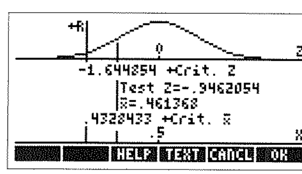
4. Enter your data, or leave the input form as it is to use the example data.
5. Press OK.
   - For hypothesis tests, a choose list appears, with the hypotheses to test against the null hypothesis. Select the hypothesis you want and press ENTER. The results of the test are displayed.
   - For confidence intervals, the results are displayed immediately.

   By default, the results are displayed in text format. The results for the one-sample Z-test example data are shown on the right.




   To change input values, or to select a different hypothesis to test, press CANCEL to return to the previous screen.

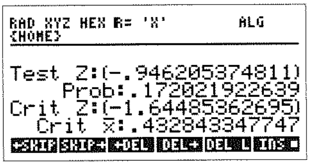
6. Press GRAPH to display the results graphically. The results for the one-sample Z-test example data are shown on the right.




   To view the results in text format, press TEXT.

7. Press OK to close the inferential statistics application and return to the default screen. The results are copied to history.

   The results for the one-sample Z-test example data appear in history as shown on the right.




## Hypothesis tests

You use hypothesis tests to test the validity of hypotheses that relate to the statistical parameters of one or two populations. The tests are based on statistics from samples of the population.

The HP 49G hypothesis tests use the Normal Z-distribution or Student's t-distribution to calculate probabilities.

### One-Sample Z-Test

**Menu name:** Z–Test: 1 $\mu$

On the basis of statistics from a single sample, measures the strength of the evidence for a selected hypothesis against the null hypothesis. The null hypothesis is that the population mean equals a specified value, $\mu_0$

You select one of the following alternative hypotheses against which to test the null hypothesis:

$$H_1 : \mu < \mu_0$$

$$H_2 : \mu > \mu_0$$

$$H_3 : \mu \neq \mu_0$$

#### Inputs

| | |
|---|---|
| $\mu_0$ | Population mean given the null hypothesis. |
| $\sigma$ | Population standard deviation. |
| $\bar{x}$ | Sample mean. |
| n | Sample size. |
| $\alpha$ | Significance level. |

### Results

| | |
|---|---|
| Test Z | Z-test statistic. |
| Prob | Probability associated with the Z-test statistic. |
| Critical Z | Boundary value of Z associated with the $\alpha$ level that you supplied. |
| Critical $\bar{x}$ | Boundary value of $\bar{x}$ required by the $\alpha$ value that you supplied. |

## Two-Sample Z-Test

**Menu name:** Z–Test: $\mu1-\mu2$

On the basis of two samples, each from a separate population, measures the strength of the evidence for a selected hypothesis against the null hypothesis. The null hypothesis is that the mean of population 1 equals the mean of population 2: $H_0$: $\mu_1 = \mu_2$

You select one of the following alternative hypotheses against which to test the null hypothesis:

$$H_1{:}\mu_1 < \mu_2$$

$$H_2{:}\mu_1 > \mu_2$$

$$H_3{:}\mu_1 \neq \mu_2$$

### Inputs

| | |
|---|---|
| $\bar{x}$ 1 | Sample 1 mean. |
| $\bar{x}$ 2 | Sample 2 mean. |
| $\sigma1$ | Population 1 standard deviation. |
| $\sigma2$ | Population 2 standard deviation. |
| n1 | Sample 1 size. |
| n2 | Sample 2 size. |
| $\alpha$ | Significance level. |

### Results

| | |
|---|---|
| Test Z | Z-test statistic. |
| Prob | Probability associated with the Z-test statistic. |
| Critical Z | Boundary value of Z associated with the $\alpha$ level that you supplied. |

## One-Proportion Z-Test

**Menu name:** Z-Test: 1 P

On the basis of statistics from a single sample, measures the strength of the evidence for a selected hypothesis against the null hypothesis. The null hypothesis is that the proportion of successes in the population equals a specified value, $\pi_0$

You select one of the following alternative hypotheses against which to test the null hypothesis:

$$H_1{:}\pi < \pi_0$$

$$H_2{:}\pi > \pi_0$$

$$H_3{:}\pi \neq \pi_0$$

### Inputs

| | |
|---|---|
| $\pi_0$ | Population proportion of successes. |
| x | Number of successes in the sample. |
| n | Sample size. |
| $\alpha$ | Significance level. |

### Results

| | |
|---|---|
| Test P | Proportion of successes in the sample. |
| Test Z | Z-test statistic. |
| Prob | Probability associated with the Z-test statistic. |
| Critical Z | Boundary value of Z associated with the $\alpha$ level that you supplied. |

Using statistics

## Two-Proportion Z-Test

**Menu name:** Z-Test: P1–P2

On the basis of statistics from two samples, each from a different population, measures the strength of the evidence for a selected hypothesis against the null hypothesis. The null hypothesis is that the proportion of successes in population 1 equals the proportion of successes in population 2: $H_0$: $\pi_1 = \pi_2$

You select one of the following alternative hypotheses against which to test the null hypothesis:

$$H_1 : \pi_1 < \pi_2$$

$$H_2 : \pi_1 > \pi_2$$

$$H_3 : \pi_1 \neq \pi_2$$



### Inputs

| | |
|---|---|
| X1 | Sample 1 mean. |
| X2 | Sample 2 mean. |
| n1 | Sample 1 size. |
| n2 | Sample 2 size. |
| $\alpha$ | Significance level. |

### Results

| | |
|---|---|
| Test P1–P2 | Difference between the proportions of successes in the two samples. |
| Test Z | Z-test statistic. |
| Prob | Probability associated with the Z-test statistic. |
| Critical Z | Boundary value of Z associated with the $\alpha$ level that you supplied. |

## One-Sample T-Test

**Menu name:** T-Test: 1 $\mu$

The One-sample T-test is used when the population standard deviation is not known. On the basis of statistics from a single sample, measures the strength of the evidence for a selected hypothesis against the null hypothesis. The null hypothesis is that the sample mean has some assumed value: $H_0 : \mu = \mu_0$

You select one of the following alternative hypotheses against which to test the null hypothesis:

$$H_1 : \mu < \mu_0$$
$$H_2 : \mu > \mu_0$$
$$H_3 : \mu \neq \mu_0$$

### Inputs

| | |
|---|---|
| $\mu 0$ | Population mean. |
| n | Sample size. |
| $\bar{x}$ | Sample mean. |
| Sx | Sample standard deviation. |
| $\alpha$ | Significance level. |

### Results

| | |
|---|---|
| Test T | T-test statistic. |
| Prob | Probability associated with the T-test statistic. |
| Critical T | Boundary value of T associated with the $\alpha$ level that you supplied. |
| Critical $\bar{x}$ | Boundary value of $\bar{x}$ required by the $\alpha$ value that you supplied. |

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## Two-Sample T-Test

**Menu name:** T-Test: μ1 – μ2

The Two-sample T-test is used when the population standard deviation is not known. On the basis of statistics from two samples, each sample from a different population, measures the strength of the evidence for a selected hypothesis against the null hypothesis. The null hypothesis is that the mean of population 1 equals the mean of population 2: $H_0$: $\mu_1 = \mu_2$

You select one of the following alternative hypotheses against which to test the null hypothesis

$$H_1{:}\mu_1 < \mu_2$$

$$H_2{:}\mu_1 > \mu_2$$

$$H_3{:}\mu_1 \neq \mu_2$$

### Inputs

| | |
|---|---|
| $\bar{x}$ 1 | Sample 1 mean. |
| $\bar{x}$ 2 | Sample 2 mean. |
| S1 | Sample 1 standard deviation. |
| S2 | Sample 2 standard deviation. |
| n1 | Sample 1 size. |
| n2 | Sample 2 size. |
| $\alpha$ | Significance level. |
| _Pooled? | Check this option to pool samples based on their standard deviations. |

### Results

| | |
|---|---|
| Test T | T-test statistic. |
| Prob | Probability associated with the T-test statistic. |
| Critical T | Boundary value of T associated with the $\alpha$ level that you supplied. |

## Confidence intervals

The confidence interval calculations that the HP 49G can perform are based on the Normal Z-distribution or Student's t-distribution.

### One-Sample Z-Interval

**Menu name:** Z–INT: 1 μ

This option uses the Normal Z-distribution to calculate a confidence interval for μ, the true mean of a population, when the true population standard deviation, σ, is known.

#### Inputs

| | |
|---|---|
| $\bar{x}$ | Sample mean. |
| σ | Population standard deviation. |
| n | Sample size. |
| C | Confidence level. |

#### Results

| | |
|---|---|
| Critical Z | Critical value for Z. |
| μ min | Lower bound for μ. |
| μ max | Upper bound for μ. |

### Two-Sample Z-Interval

**Menu name:** Z–INT: μ1– μ2

This option uses the Normal Z-distribution to calculate a confidence interval for the difference in the means of two populations, $\mu_1$ and $\mu_2$, when the population standard deviations, $\sigma_1$ and $\sigma_2$ are known.

#### Inputs

| | |
|---|---|
| $\bar{x}$ 1 | Sample 1 mean. |
| $\bar{x}$ 2 | Sample 2 mean. |
| σ1 | Population 1 standard deviation. |
| σ2 | Population 2 standard deviation. |
| n1 | Sample 1 size. |
| n2 | Sample 2 size. |
| C | Confidence level. |

#### Results

| | |
|---|---|
| Critical Z | Critical value for Z. |
| $\Delta\mu$ Min | Lower bound for $\mu_1 - \mu_2$ |
| $\Delta\mu$ Max | Upper bound for $\mu_1 - \mu_2$ |

## One-Proportion Z-Interval

**Menu name:** Z–INT: 1 P

This option uses the Normal Z-distribution to calculate a confidence interval for the proportion of successes in a population for the case in which a sample of size, $n$, has a number of successes, $x$.

#### Inputs

| | |
|---|---|
| x | Sample success count. |
| n | Sample size. |
| C | Confidence level. |

#### Results

| | |
|---|---|
| Critical Z | Critical value for Z. |
| $\pi$ Min | Lower bound for $\pi$. |
| $\pi$ Max | Upper bound for $\pi$. |

## Two-Proportion Z-Interval

**Menu name:** Z–INT: P1 – P2

This option uses the Normal Z-distribution to calculate a confidence interval for the difference in the proportions of successes in two populations.

#### Inputs

| | |
|---|---|
| x1 | Sample 1 success count. |
| x2 | Sample 2 success count. |
| n1 | Sample 1 size. |
| n2 | Sample 2 size. |
| C | Confidence level. |

### Results

| | |
|---|---|
| Critical Z | Critical value for Z. |
| $\Delta\pi$ Min | Lower bound for the difference in proportions of successes. |
| $\Delta\pi$ Max | Upper bound for the difference in proportions of successes. |

## One-Sample T-Interval

**Menu name:** T–INT: 1 $\mu$

This option uses the Student's t-distribution to calculate a confidence interval for $\mu$, the true mean of a population, for the case in which the true population standard deviation, $\sigma$, is unknown.

### Inputs

| | |
|---|---|
| $\bar{x}$ | Sample mean. |
| Sx | Sample standard deviation. |
| n | Sample size. |
| C | Confidence level. |

### Results

| | |
|---|---|
| Critical T | Critical value for T. |
| $\mu$ Min | Lower bound for $\mu$. |
| $\mu$ Max | Upper bound for $\mu$. |

## Two-Sample T-Interval

**Menu name:** T–INT: μ1 – μ2

This option uses the Student's t-distribution to calculate a confidence interval for the difference in the means of two populations, $\mu_1 - \mu_2$, when the population standard deviations, $\sigma_1$ and $\sigma_2$, are unknown.

### Inputs

| | |
|---|---|
| $\bar{x}$ 1 | Sample 1 mean. |
| $\bar{x}$ 2 | Sample 2 mean. |
| s1 | Sample 1 standard deviation. |
| s2 | Sample 2 standard deviation. |
| n1 | Sample 1 size. |
| n2 | Sample 2 size. |
| C | Confidence level. |
| _Pooled | Whether or not to pool the samples based on their standard deviations. |

### Results

| | |
|---|---|
| Critical T | Critical value for T. |
| Δ μ Min | Lower bound for $\mu_1 - \mu_2$. |
| Δ μ Max | Upper bound for $\mu_1 - \mu_2$. |

Using statistics

# Chapter 10

# Introduction to programming

## Contents

# Introduction

This chapter describes how to create and run programs on the HP 49G. The HP 49G has a rich programming environment. Programs can range in complexity from a simple task such as performing a sequence of arithmetic operations, to a complex process that requests input, performs extensive processing, and outputs results in a graphical format.

This chapter focuses on creating and running programs in algebraic mode only. See the *Advanced User's Guide* for information on creating and using programs in RPN mode. See the *Pocket Guide* for details of the programming commands that are available.

# Getting started

This section contains an example of how to create a simple program to calculate the hypotenuse of a right-angle triangle, using Pythagoras' theorem. When you start the program, you supply the known side lengths as arguments.

This program is an example of a simple algebraic calculation using the arguments that you specify. Within the program, the calculation is enclosed in single quotes ([↱] [']) to delimit it as an algebraic object. If you need to do extensive processing involving looping and branching, you use a nested procedure ([↱] [« »]) to delimit the procedure from the arguments.

The program does the following:

- It collects the known side lengths as arguments and stores them as local variables, that is, variables that exist only while the program is running.
- It uses the variables to calculate the length of the hypotenuse, and returns the result to the history.

Create the program as follows:

1. Put the program delimiters on the command line.

   [↱] [« »] « »

2. Define the two local variables to accept the arguments for the side length.

   [↱] [→] [ALPHA] A [SPC] [ALPHA] B [SPC] « → A B »

3. Define the equation to calculate the hypotenuse.

   Note that you need to use (') to enclose the equation and separate it from the definition of the arguments.

   (↱)(')(√x)(↰)(()) (ALPHA)A(y^x)2
   (+)(ALPHA)B(y^x)2 « → A B '√(A^2+B^2)' »

4. Move the cursor out of the program and specify that you want to store the program as "PYTH".

   (↱)(▼)(STO▸)(ALPHA)(ALPHA)PYTH « →A B '√(A^2+B^2)' » ▶ PYTH

5. Press (ENTER) to store the program.

   (ENTER)

When you run the program, you specify the lengths of the sides as arguments to the program. For example, to run the program to calculate the hypotenuse of a right angle triangle with sides of 3 and 4 units:

1. Display a list of the variables in the directory.

   (VAR)

2. Press the function key that corresponds to your program. The program name is inserted on the command line. Press (↰)(()) to insert parentheses after the program name.

3. Enter your arguments, separated by a (↱)(,), between the parentheses.

   3(↱)(,)4

4. Press (ENTER) to calculate the hypotenuse.

   (ENTER)

   The result is returned to history.

# Creating, saving, and running a program

A program is an object that you can store in a variable. That is, you create a program, assign it a name and save it in a directory.

- To create a program, press (↱)(« »). The program delimiters appear on the command line ready for you to enter code, and the PRG annunciator appears at the top of the screen to indicate that you are in program mode.

  Use the keyboard functions and keys, and select commands from the programming menu, to create your program. As you select function keys and operator keys, the functions and operations appear in your program.

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Use ; to separate functions and calculations within a nested procedure. To enter ;, press and hold down (right-shift), and press (SPC).

For readability, you can use (right-shift)(←) to add line breaks.

For details on editing a program—for example cutting, copying, and pasting code—see See "Editing the command line" on page 2-13.

- To save your program:
  a. Press (right-shift)(▼) to move the cursor past the end of the program.
  b. Press (STO▸) to insert the ▸ symbol after the program.
  c. Enter a name for the program, and press (ENTER).
- To run a program:
  a. Access the directory where the program resides and either enter the program name on the command line, or press (VAR) and select it from the function-key menu.

     The program name should now be on the command line.
  b. Press (left-shift)(( )) to insert parentheses after the program name.
  c. Enter the argument or arguments separated by a (right-shift)(,), and press (ENTER).

## The programming menu

The programming menu contains the commands you can use in a program. Select a category to display the available commands in that category. From the menu, you select commands to include in your program. The programming menu is a typing aid only. You need to know the syntax of the commands, and how to use them in your program. See the pocket guide for details of programming commands and their syntax.

Examining the programming menu is a good way to get an idea of the types of programming operations that are available on the HP 49G.

To display the programming menu, press (left-shift)(PRG).

# Algebraic and RPN modes

In RPN mode, the HP 49G makes extensive use of the stack. When developing programs in RPN mode, you use the stack to:

- provide the data that your program uses
- construct the commands that your program uses
- hold the output that your program generates.

In algebraic mode, the stack is not available. You use other methods to build your program and to pass data to it.

## Using functions that require arguments

When using a function that requires arguments:

- In RPN mode, you place the arguments on the stack before calling the function.
- In algebraic mode, you supply the arguments, enclosed in parentheses, after the function call.

For example, you can use the INPUT command to prompt for data. The following code segments demonstrate how to use the INPUT command to collect data in both RPN and algebraic modes.

- In RPN mode, the following code segment prompts for input, collects the data as a string and converts it to a number. At the end of the process, the data is on level 1 of the stack:

```
« "ENTER A NUMBER"
""
INPUT
OBJ→ »
```

- In Algebraic mode, the following code segment performs the same operation. At the end of this process, the data is stored in a global variable, NUM1, ready for use in the program.

  Note that, since you are using a global rather than a local variable, you can follow the variable declaration with a function.

```
« INPUT ("ENTER A NUMBER","") ▶ NUM1;
OBJ→(NUM1) ▶ NUM1 »
```

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# Handling data

This section briefly describes how you can supply data to your programs, and how you can output data that your programs produce.

## Input data

You can use one of the following methods to specify the data that you want your program to use:

- as arguments when you run the program
- as variables that you create in memory before you run the program
- by prompting for input as the program runs.
  - See "Using functions that require arguments" on page 10-5 for an example of using the INPUT function to prompt for data.
  - When you use a function such as INPUT to collect numeric data while the program runs, the data is returned as a string. You need to convert it to a number using a function such as OBJ→.

## Output data

Data that is output in algebraic mode is written to the history. Note the following points regarding output:

- When the program completes, the history displays the last output only. This is displayed at level 1. To retain outputs created during processing, you can write the output to a global variable or variables as the program progresses. This method gives you the flexibility to format the output, and to add comments to improve clarity.
- Some functions return multiple values. For these functions, values are written to a list. Unless you output to a variable, the list appears on the history.

# How a program flows

HP 49G programs have one entrance point—at the beginning of the program—and one exit point—at the end of the program. There is no command such as GOTO that you can use to jump to a point within a program. Within a program, you use looping and branching structures such as `IF THEN` to control the order of operations. See "Conditional and looping structures" on page 10-13 for details.

You can run other programs from within your programs. In this manner, you can create modular programs. For example, you could create three discrete component programs named INPUT, PROCESSING, and OUTPUT. You could then create a master program that runs each of these components in turn, as follows:

```
« INPUT PROCESSING OUTPUT »
```

## Nested procedures

If you use local variables to collect input arguments, you need to use nested procedures if you want to perform branching and looping. You cannot perform branching and looping from within an algebraic object.

To insert a new nested procedure in your code, press ↱ «» to insert the delimiters. Enter the procedure code between the delimiters.

For example, in the following programming segment, the input arguments are assigned to variables A and B. The algebraic object, a calculation that adds the variables, needs to be enclosed in single quotes as it immediately follows the local variable definition. This example returns the sum of A and B to the history.

```
« → A B 'A+B' »
```

In the following programming segment you use a nested procedure, as the processing involves more than a simple calculation. This example compares A and B, and carries out calculations based on the comparison. The results of the calculations are stored in global variables C and D.

```
« → A B
  « IF A>B
    THEN A-B ▶ C; A^2-B^2 ▶ D
      ELSE B-A ▶ C
    END
  »
»
```

Note that within a nested procedure, you need to use ; to separate calculations. To insert a ; character, press and hold ↱ and press SPC.

# Working with variables

You use variables to hold data within your programs. There are two types of variables within the HP 49G programming environment.

- You create **local variables** within your program. For example, local variables hold the values set by the arguments you use when you call the program.

  A program can only access a local variable inside the nested procedure where it was created, and any nested procedures that it contains.

- You can create **global variables** in a program or you can use existing global variables. See chapter 7, "Storing objects" for details on how to create global variables. Note the following points:
  - Global variables are available anywhere within a program.
  - To remove a global variable using code, use the PURGE command.
  - If you use global variables in your program, they must be located in the same directory, or higher, as the program.

## Using local variables

There are some constraints with local variables that you need to be aware of. These are as follows:

- Immediately after a local variable declaration, the program code must contain either:
  - an algebraic calculation enclosed in single quotes
  - a nested procedure enclosed by « ».
- A local variable is available in the nested procedure where it was created, and all nested procedures that it contains.
- You can create a local variable with the same name as an existing global variable (that is, a variable in the same directory or higher as the program). Commands that use the variable name will use the local variable value rather than the global variable value.

## Setting variables

You generally set variables to inputs or to the results of processes and calculations that your program performs. You can use local variables to store intermediate results that you want to re-use in subsequent nested procedures within your program. Use global variables to store data for wider access.

## Setting local variables to hold input arguments

1. On the command line, position the cursor immediately to the right of the opening « symbol.
2. Press [↱][−] to insert the → symbol.
3. Enter a local variable name for each input argument your program uses, separating each with a [SPC].

For example, if your program uses two arguments, and you want to set the value of these arguments to local variables A and B, the beginning of your program would appear as follows:

[↱][« »][↱][−][ALPHA]A[SPC][ALPHA]B

```
« → A B
```

## Setting a local variable to a value

After the value, press [↱][−] to insert the → symbol, and enter the local variable name.

For example, to set local variable G to hold 9.81, the acceleration of gravity, you create the variable as follows:

[↱][« »] 9.81[↱][−][ALPHA]G

```
« 9.81 → G »
```

The following example:

- accepts an input argument
- creates the local variable G
- multiplies it by the argument, and places the result on the history.

```
« → A
 « 9.81 → G
  « A*G »
 »
»
```

In the following example, the A*G calculation does not recognize the local variable G as 9.81, as it is outside the nested procedure where the variable was declared. The A+G calculation recognizes G as 9.81

```
« → A
 « 9.81 → G 'A+G' »
A*G
»
```

## Setting a local variable to the result of a calculation

The following program segment demonstrates how to set a local variable to the result of a calculation, and to use the result in a subsequent calculation. The program accepts two input arguments and uses these in the calculations.

1. On the command line, insert the program delimiters and specify the local variables to hold the input arguments.

   (↱)(« »)(↱)(→)(ALPHA)A(SPC)(ALPHA)B(SPC)

   ```
   « → A B
   »
   ```

2. Start a new nested procedure and define the initial calculation.

   (↱)(« »)(ALPHA)A(+)(ALPHA)B

   ```
   « → A B
   « A+B
   »
   »
   ```

3. Store the results of the calculation to local variable C.

   (↱)(→)(ALPHA)C

   ```
   « → A B
   « A+B → C
   »
   »
   ```

4. Open a new nested procedure and enter a calculation that uses the result of the initial calculation.

   (↱)(« »)(ALPHA)C(+)(√x)(↰)( )(ALPHA)A(−)(ALPHA)B
   (↱)(→)(ALPHA)C

   ```
   « → A B
   « A+B → C
   « C+√ (A-B)
   »
   »
   »
   ```

## Using global variables

You can use existing global variables in your programs. Global variables are different to local variables in the following ways:

- Global variables are available to the entire program, independent of nested procedures.
- Unlike local variables, you can create more than one global variable in a nested procedure.

Within a program, you use the (STO▶) key to define a global variable. The (STO▶) key produces a ▶ symbol on the command line.

## Example

The following program demonstrates the use of a global variable to hold the data a program uses, and to hold the output it produces. It performs the following tasks:

- It accepts an input argument and calculates its percentage of a value in the global variable "TOTL". You create TOTL before you run the program.
- It stores the result into another global variable, "RESLT1".
- It converts the numeric result to a string and adds "%" for readability.

To create the program, perform the following:

1. Insert the program delimiters onto the command line and define the input variable.

   (↱)(« »)(↱)(→)(ALPHA)A

   ```
   « → A
   »
   ```

2. Create a new nested procedure.

   (↱)(« »)

   ```
   « → A
   «
   »
   »
   ```

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3. Enter the percentage calculation.
   ⇦ ( ) ALPHA A ÷ ALPHA ALPHA TOTL ALPHA ▶ × 100

```
« → A
« (A/TOTL)*100

»
»
```

4. Store the results into the global variable "RESLT1". Note that after the calculation, you need to insert a ; to delimit the algebraic commands (hold down ⇨ and press SPC).
   STO▶ ALPHA ALPHA RESLT1 ALPHA ⇨ SPC

```
« → A
« (A/TOTL)*100 ▶ RESLT1;

»
»
```

5. Add "%" and save the resulting string back into RESLT1. Note the following:
   - To insert the % symbol, use the Characters tool (⇨ CHARS) or press ALPHA ⇦ 1.
   - When you add a string to a number, the resulting value is a string. You do not need to convert the number.

   ALPHA ALPHA RESLT1 ALPHA + " " SPC ⇨ CHARS % ENTER ▶ STO▶ ALPHA ALPHA RESLT1

```
« → A
« (A/TOTL)*100 ▶ RESLT1 ;
RESLT1+" %" ▶ RESLT1

»
»
```

Before you run this program, create a global variable named "TOTL" and assign a number to it.

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# Looping and branching

This section introduces the use of conditional branching and looping within a program. Conditional structures evaluate 0 as false, and any other value as true.

## Comparison functions

The HP 49G provides comparison functions that you can use in conjunction with the conditional and looping structures. You access them from the Programming Test menu. For example, to test A in relation to B, use the following:

| | |
|---|---|
| `A==B` | Returns true if A equals B. |
| `A≠B` | Returns true if A does not equal B. |
| `A<B` | Returns true if A is less than B. |
| `A>B` | Returns true if A is greater than B. |
| `A≤B` | Returns true if A is less than or equal to B. |
| `A≥B` | Returns true if A is greater than or equal to B. |
| `SAME(A,B)` | Returns true if A is exactly the same object as B. |

## Conditional and looping structures

The following conditional and looping commands are available:

- **IF** *comparison* **THEN** *code* **END**

  If *comparison* evaluates to true, that is a non-zero value, runs *code*.

- **IF** *comparison* **THEN** *code-1* **ELSE** *code-2* **END**

  If *comparison* evaluates to true, runs *code-1*. If *comparison* evaluates to false, *code-2* is run.

- **CASE** *expression-1* **THEN** *code-1* **END**
  *expression-2* **THEN** *code-2* **END**
  . . .
  *expression-n* **THEN** *code-n* **END**
  **END**

  Runs the code that corresponds to the first expression in the structure that evaluates to true.

- **START** (*start*, *end*) *code* **NEXT**

  Runs *code*, increments *start*. Repeats until *start* > *end*. The *code* is always run at least once.

- **START** (*start*, *end*) *code* **STEP** *(incr)*

  Runs *code*, increments *start* by the number specified by *incr*. (*incr* can be an expression.) Repeats until *start* > *end*. The *code* is always run at least once.

- **FOR** (*var*, *start*, *end*) *code* **NEXT**

  Runs *code*, sets *var* to *start*. Increments *var*, and repeats until *var* > *end*. This is similar to **START... NEXT** except that you can use *var* in your code.

- **FOR** (*var*, *start*, *end*) *code* **STEP** *(incr)*

  Runs *code*, increments *var* by the number specified by *incr*. (*incr* can be an expression.) Repeats until *start* > *end*. This is similar to **START** ... **STEP** except that you can use *var* in your code.

- **DO** *code* **UNTIL** *comparison* **END**

  Runs *code*, then tests to see if *comparison* evaluates to true. Ends if it does. Repeats *code* if it does not. The *code* is always run at least once.

- **WHILE** *comparison* **REPEAT** *code* **END**

  Checks if *comparison* evaluates to true. Runs *code* if it does. Repeats until test returns false. This is similar to **DO** ...**UNTIL** except that *code* is not run if *comparison* evaluates to false the first time.

## Example

The following example processes a list of numeric values that is stored in a variable named MARKS. It performs the following:

- It determines the number of elements in the list.
- For each element in the list, the program compares the element to the pass value:
  a. If the element is greater than or equal to the pass value, inserts "Pass" after the value.
  b. If the element is less than the pass mark, inserts "Fail" after the value. Note that this converts the value to a string.
- It replaces the original value with the string.

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```
« @ Local variable S is used
@ to store the step number.
@ Step from 1 to the size of the list.
FOR(S,1,SIZE(MARKS))
@ Extracts the element from the list
  GET(MARKS,S) → E
@ Compares it to the pass mark, amends and
@ replaces with the new value.
   « IF E≥50 THEN
      E+" Pass" ▶ E
   ELSE
      E+" Fail" ▶ E
   END ;
   REPL(MARKS,S,{E})▶MARKS
» ;
NEXT
»
```

# Trapping errors

By default, a program halts when it encounters an error. If you want sections of your program to deal with errors rather than halt the program, you need to include the sections inside error trapping structures. You can then specify actions to take when your program encounters errors, rather than halting the program. The following error trapping structures are available.

- **IFERR** *code* **THEN** *error-code* **END**

  If the program encounters an error while it is running *code*, the remaining code is skipped and *error-code* is run. If no errors are encountered in *code*, *error-code* is not run.

- **IFERR** *code* **THEN** *error-code* **ELSE** *noerror-code* **END**

  If the program encounters an error while it is running *code*, the remaining code is skipped and *error-code* is run. If no errors are encountered in *code*, *noerror-code* is run.

## Example

The following example creates the list of marks used in the previous example. If a non-numeric value is entered, the program prompts with an error message. The program performs the following:

- It sets up a loop to collect 20 values.
- It prompts for an input value.
- It tests the input to check if it is a number.
- If the generates an error, the error is trapped, and an error message is displayed to prompt for a numeric value.

```
«
@ Set numeric mode so that error trap works
SF(-3) ;
@ Create an empty list
{}▶MARKS ;
@ Set up a loop for 20 entries.
WHILE SIZE(MARKS)<20 REPEAT
@ Start error-checking routine.
IFERR INPUT("Enter a number","") → N
@ Attempt to convert the entry to a number.
@ This generates an error if non-numeric
« OBJ→(N)+1-1 → N
@ If no error, append the entry to the list.
« MARKS+N ▶ MARKS
»
»
THEN
@This appears if entry is non-numeric.
MSGBOX("INVALID ENTRY, TRY AGAIN")
END ;
END
»
```

Introduction to programming

# Appendix A

# Connecting to another calculator

## Contents





## Introduction

This appendix describes how to use the serial cable that comes with the HP 49G to connect to another calculator. Connect to another calculator when you want to exchange objects—for example, programs or data—between calculators.

To transfer data or programs between your calculator and a PC, you need to purchase a Hewlett-Packard Connectivity Kit. You can also use a connectivity kit to load new versions of the calculator's software.

# Transferring objects between calculators

You can transfer single objects between calculators, or you can send multiple objects and directories.

- You use File Manager to select objects to transfer between calculators.
- You use the serial cable that comes with the HP 49G to connect the calculators and transfer objects between them.

# Transferring data between two HP 49Gs

1. Ensure that the calculators are connected correctly.
2. On the sending calculator, navigate to the directory that contains the objects to send, and on the receiving calculator, navigate to the directory where you want to store the received objects.
3. On both calculators, press APPS, then 2 and ENTER to select I/O FUNCTIONS.
4. On the receiving calculator, press 2, then ENTER to select GET FROM HP 49. The receiving calculator connects to the sending calculator.
5. On the sending calculator:
   a. Press ENTER to select SEND TO HP 49. The Send to HP 49 input form is displayed.
   b. Press CHOOS to display the objects in the current directory.
   c. Use the arrow keys to highlight an object to send and press CHECK to select it. Repeat this step for other objects you want to send.
   d. Press OK to return to the Send to HP 49 input form.
   e. Press SEND. The objects that you selected are transmitted to the receiving calculator.

# Transferring objects to or from an HP 48

To transfer objects between an HP 49G and an HP 48 series calculator, you need to use the connection adaptor that is supplied with the HP 49G.

You can only transfer objects you have created between the HP 49G and the HP 48 series. If you attempt to transfer other objects, it may cause errors.

1. Fit the adaptor to an end of the connection cable.
2. Attach the adaptor end of the cable to the HP 48's serial port, and the other end to the HP 49G's serial port.
3. On both the HP 49G and the HP 48, navigate to the directory where you want to send or receive objects.

4. On the HP 49G:
   a. Press (APPS) to display the Applications choose list.
   b. Select I/O FUNCTIONS and press (ENTER) to display the I/O Functions choose list.
   c. Select TRANSFER to display the Transfer input form.


5. On the HP 48:
   a. Press (⮣) (1) (**[I/O]**) to display the I/O Functions choose list.
   b. Select TRANSFER and press (ENTER) to display the Transfer input form.
6. On both calculators, edit the input forms to ensure that the FMT: option is set to ASC. The other settings on both forms must match.
7. On the sending calculator:
   a. Press CHOOS and select LOCAL VARS to display objects in the current directory.
   b. Select the object to send and press (ENTER) to place it in the Name field.
   c. Press SEND to send the object.
8. On the receiving calculator, press RECV. The object is sent from the sending calculator to the receiving calculator. It appears in the current directory.

# Appendix B

# Error messages

## Introduction

This appendix contains the main error messages that the HP 49G can generate. The messages are listed in alphabetical order.

| Message | Meaning |
|---|---|
| Alarm | An alarm has not been acknowledged. |
| Bad Argument Type | One or more arguments for an operation was of an incorrect type for the operation. |
| Bad Guesses | The guess(es) supplied to the equation solver lie outside the domain of the equation. |
| Can't Edit Null Character | You attempted to edit a string containing a character with code 0. |
| Circular Reference | You attempted to store a variable name into itself. |
| Directory Not Allowed | You attempted to use a directory as an argument. |
| Directory Recursion | You attempted to store a directory into itself. |
| EQ Invalid For MINIT | The EQ variable must contain at least two equations and two variables. |
| HALT Not Allowed | A program that contains the HALT comand ran while an application that does not allow HALT was running, for example Matrix Writer. |
| Inconsistent Units | The units conversion that you are attempting has incompatible units |

Error messages

| Message (Continued) | Meaning |
|---|---|
| Infinite Result | A calculation that produces an infinite result has been attempted, for example, 1/0. |
| Insufficient Memory | There is not enough memory available to complete the operation |
| Insufficient ΣData | A statistics command was run when there was not enough data in ΣDAT for a calculation. |
| Interrupted | CANCEL was pressed while the solve application or the root finder was working. |
| nvalid Array Element | You attempted to enter an object of an incompatible type into an array. |
| Invalid Card Data | You need to initialize the calculator's ports. See page D-6 for instructions. |
| Invalid Dimension | The array argument has invalid dimensions. |
| Invalid EQ | The EQ variable contains an equation that is incompatible with the operation that you are attempting. |
| Invalid IOPAR | One or more of the I/O parameters is invalid. |
| Invalid Name | A file with an illegal name has been requested for sending, or receiving. |
| Invalid PPAR | One or more of the plotting parameters is invalid. |
| Invalid PTYPE | The requested plot type is invalid for the current equation. |
| Invalid Repeat | The alarm repeat interval that you requested is out of range. |
| Invalid Syntax | The OBJ or the STR command was unable to convert the specified data. |

| Message (Continued) | Meaning |
|---|---|
| Invalid Time | The time argument is invalid. |
| Invalid Unit | The unit argument is invalid for the attempted operation. |
| Invalid ΣData | The data in ΣDAT is invalid for the attempted statistics command. |
| LowBat() | Replace the calculator batteries. |
| Low Battery | The system batteries are too low to perform the I/O operation. |
| Name Conflict | The Where function attempted to assign a value to the variable of integration or the summation index. |
| No Current Equation | The operation requires an equation in the EQ variable and there is no equation in the variable. |
| No Stat Data to Plot | You selected a statistical plot and there is no data in ΣDAT. |
| Non-empty Directory | The directory that you are attempting to purge contains data. |
| Non-existent Alarm | The Alarm command was used to specify a non-existant alarm. |
| Non-existent ΣDAT | A statistics command was used when there was no data in ΣDAT. |
| Out of Memory | The calculator has no available memory. You need to purge objects to free memory in order to continue operations. |
| Overflow | A calculation returned a value that is greater than the maximum size that the HP 49G can handle. |
| Positive Underflow | A calculation returned a result smaller than the minimum size that the calculator can handle. |

| Message (Continued) | Meaning |
|---|---|
| Power Lost | Appears when the calculator is turned on after a power loss. The power loss may have caused objects in memory to be lost. |
| Too few arguments | You attempted to run a command or function and did not supply all the required arguments. |
| Undefined result | A calculation returned a result that the calculator is unable to define mathematically, for example, 0/0. |

# Appendix C

# Units

The HP 49G contains a catalog of 127 units that you can use to create *unit objects*. A unit object is a real number linked to a unit expression by the underscore character. For example, **2_in** is a unit object representing 2 inches.

The calculator's units are based on the 7 base units of the International System of Units: *m* (meter), *kg* (kilogram), *s* (second), *A* (ampere), *K* (kelvin), *cd* (candela), and *mol* (mole). The HP 49G makes use of two additional base units: *r* (radian) and *sr* (steradian). The remaining 118 units are compound units, that is, units derived from the 9 base units.

You select a unit by pressing ⓡ UNITS, choosing the appropriate category from the Units menu—length, area, volume, etc.—and finally selecting the unit from the category submenu. You do this when creating a unit object or when converting one unit to another. You can also perform calculations using unit objects. (See *Advanced User's Guide* at http://www.hp.com/calculators/hp49 for more information.)

| Unit (Full Name) | Value in SI Units |
|---|---|
| a (are) | 100 $m^2$ |
| A (ampere) | 1 A |
| acre (acre) | 4046.87260987 $m^2$ |
| arcmin (minute of arc) | 2.90888208666 $\times 10^{-4}$ r |
| arcs (second of arc) | 4.8481368111 $\times 10^{-6}$ r |
| atm (atmosphere) | 101325 kg/m·$s^2$ |
| au (astronomical unit) | 1.495979 $\times 10^{11}$ m |
| Å (angstrom) | 1 $\times 10^{-10}$ m |
| b (barn) | 1 $\times 10^{-28}$ $m^2$ |
| bar (bar) | 100000 kg/m·$s^2$ |

| Unit (Full Name) (Continued) | Value in SI Units |
|---|---|
| bbl (barrel) | 0.158987294928 $m^3$ |
| Bq (becquerel) | 1 $s^{-1}$ |
| Btu (British thermal unit) | 1055.05585262 $kg{\cdot}m^2/s^2$ |
| bu (bushel) | 0.03523907 $m^3$ |
| °C (degree Celsius) | 274.15 K [°C + 273.15] |
| c (speed of light) | 299792458 m/s |
| C (coulomb) | 1 A·s |
| cal (calorie) | 4.1868 $kg{\cdot}m^2/s^2$ |
| cd (candela) | 1 cd |
| chain (chain) | 20.1168402337 m |
| Ci (curie) | $3.7 \times 10^{10}$ $s^{-1}$ |
| ct (carat) | 0.0002 kg |
| cu (US cup) | $2.365882365 \times 10^{-4}$ $m^3$ |
| ° (degree) | $1.74532925199 \times 10^{-2}$ r |
| d (day) | 86400 s |
| dB (decibel) | 1 dB |
| dyn (dyne) | 0.00001 $kg{\cdot}m/s^2$ |
| erg (erg) | 0.0000001 $kg{\cdot}m^2/s^2$ |
| eV (electron volt) | $1.60217733 \times 10^{-19}$ $kg{\cdot}m^2/s^2$ |
| F (farad) | 1 $A^2.s^4/kg{\cdot}m^2$ |
| °F (degrees Fahrenheit) | 255.927777778 K |
| fath (fathom) | 1.82880365761 m |
| fbm (board foot) | 0.002359737216 $m^3$ |
| fc (foot-candle) | 10.7639104167 $cd{\cdot}sr/m^2$ |

Units

| Unit (Full Name) (Continued) | Value in SI Units |
|---|---|
| Fdy (faraday) | 96487 A·s |
| fermi (fermi) | $1 \times 10^{-15}$ m |
| flam (foot-lambert) | 3.42625909964 cd/$m^2$ |
| ft (international foot) | 0.3048 m |
| ftUS (survey foot) | 0.304800609601 m |
| g (gram) | 0.001 kg |
| ga (standard freefall) | 9.80665 m/$s^2$ |
| gal (US gallon) | 0.003785411784 $m^3$ |
| galC (Canadian gallon) | 0.00454609 $m^3$ |
| galUK (UK gallon) | 0.004546092 $m^3$ |
| gf (gram-force) | 0.00980665 kg·m/$s^2$ |
| gmol (gram-mole) | 1 mol |
| grad (gradients) | $1.57079632679 \times 10^{-2}$ r |
| grain (grain) | 0.00006479891 kg |
| Gy (gray) | 1 $m^2/s^2$ |
| H (henry) | 1 kg·$m^2/A^2 \cdot s^2$ |
| ha (hectare) | 10000 $m^2$ |
| h (hour) | 3600 s |
| hp (horsepower) | 745.699871582 kg·$m^2/s^3$ |
| Hz (hertz) | 1 $s^{-1}$ |
| in (inch) | 0.0254 m |
| inHg (inches of mercury, 0°C) | 3386.38815789 kg/m·$s^2$ |
| $inH_20$ (inches of water, 60°F) | 248.84 kg/m·$s^2$ |
| J (joule) | 1 kg·$m^2/s^2$ |

Units

| Unit (Full Name) (Continued) | Value in SI Units |
|---|---|
| K (kelvin) | 1 K |
| kg (kilogram) | 1 kg |
| kip (kilopound-force) | 4448.22161526 $kg{\cdot}m/s^2$ |
| knot (nautical miles per hour) | 0.514444444444 m/s |
| kph (kilometers per hour) | 0.277777777778 m/s |
| l (liter) | 0.001 $m^3$ |
| lam (lambert) | 3183.09886184 $cd/m^2$ |
| lb (avoirdupois pound) | 0.45359237 kg |
| lbf (pound-force) | 4.44822161526 $kg{\cdot}m/s^2$ |
| lbmol (pound-mole) | 453.59237 mol |
| lbt (troy pound) | 0.3732417216 kg |
| lm (lumen) | 1 cd·sr |
| lx (lux) | 1 $cd{\cdot}sr/m^2$ |
| lyr (light year) | $9.46052840488 \times 10^{15}$ m |
| m (meter) | 1 m |
| µ (micron) | $1 \times 10^{-6}$ m |
| mho (mho) | 1 $A^2{\cdot}s^3/kg{\cdot}m^2$ |
| mi (international mile) | 1609.344 m |
| mil (mil) | 0.0000254 m |
| min (minute) | 60 s |
| miUS (US statute mile) | 1609.34721869 m |
| mmHg (millimeter of mercury, or torr) | 133.322368421 $kg/m{\cdot}s^2$ |
| mol (mole) | 1 mol |
| mph (miles per hour) | 0.44704 m/s |

| Unit (Full Name) (Continued) | Value in SI Units |
|---|---|
| N (newton) | 1 $kg{\cdot}m/s^2$ |
| nmi (nautical mile) | 1852 m |
| $\Omega$ (ohm) | 1 $kg{\cdot}m^2/A^2{\cdot}s^3$ |
| oz (ounce) | 0.028349523125 kg |
| ozfl (US fluid ounce) | $2.95735295625 \times 10^{-5}$ $m^3$ |
| ozt (troy ounce) | 0.03110341768 kg |
| ozUK (UK fluid ounce) | $2.8413075 \times 10^{-5}$ $m^3$ |
| P (poise) | 0.1 $kg/m{\cdot}s$ |
| Pa (pascal) | 1 $kg/m{\cdot}s^2$ |
| pc (parsec) | $3.08567818585 \times I0^{16}$ m |
| pdl (poundal) | 0.138254954376 $kg{\cdot}m/s^2$ |
| ph (phot) | 10000 $cd{\cdot}sr/m^2$ |
| pk (peck) | 0.0088097675 $m^3$ |
| psi (pounds per square inch) | 6894.75729317 $kg/m{\cdot}s^2$ |
| Pt (pint) | 0.000473176473 $m^3$ |
| qt (quart) | 0.000946352946 $m^3$ |
| r (radian) | 1 r |
| R (röntgen) | 0.000258 $A{\cdot}s/kg$ |
| °R (degrees Rankine) | 0.555555555556 K |
| rad (rad) | 0.01 $m^2/s^2$ |
| rd (rod) | 5.02921005842 m |
| rem (rem) | 0.01 $m^2/s^2$ |
| rpm (revolutions per minute) | 0.0166666666667 $s^{-1}$ |
| s (second) | 1 s |

Units

| Unit (Full Name) (Continued) | Value in SI Units |
|---|---|
| S (siemens) | 1 $A^2 \cdot s^3/kg \cdot m^2$ |
| sb (stilb) | 10000 $cd/m^2$ |
| slug (slug) | 14.5939029372 kg |
| sr (steradian) | 1 sr |
| st (stere) | 1 $m^3$ |
| St (stokes) | 0.0001 $m^2/s$ |
| Sv (sievert) | 1 $m^2/s^2$ |
| t (metric ton, or tonne) | 1000 kg |
| T (tesla) | 1 $kg/A \cdot s^2$ |
| tbsp (tablespoon) | $1.47867647813 \times 10^{-5}$ $m^3$ |
| therm (EEC therm) | 105506000 $kg \cdot m^2/s^2$ |
| ton (short ton) | 907.18474 kg |
| tonUK (long ton) | 1016.0469088 kg |
| torr (torr) | 133.322368421 $kg/ms^2$ |
| tsp (teaspoon) | $4.92892159375 \times 10^{-6}$ $m^3$ |
| u (unified atomic mass) | $1.6605402 \times 10^{-27}$ kg |
| V (volt) | 1 $kg \cdot m^2/A \cdot s^3$ |
| W (watt) | 1 $kg \cdot m^2/s^3$ |
| Wb (weber) | 1 $kg \cdot m^2/A \cdot s^2$ |
| yd (international yard) | 0.9144 m |
| yr (year) | 31556925.9747 s |

# Appendix D

# Troublehooting

## Contents



## Introduction

This appendix provides help in understanding and overcoming problems that might occur with the HP 49G.

To ensure the reliability and proper functioning of your calculator—and not void your warranty—you should only store and use it within the following environmental limits:

**Operating temperature:** 0° to 55° C (32° to 131° F)

**Storage temperature:** –40 to 70° C (–40° to 158° F)

**Maximum operating humidity:** 90% at 40° C (104° F).

Troubleshooting

# Calculator will not turn on

This condition most likely indicates that the batteries have run out. Install new batteries and see if the condition persists.

If, after replacing the batteries, the calculator still does not turn on when you press ON, follow the steps set out in “Resetting the calculator” below.

If the calculator does turn on but the main display is blank:

1. press and hold ON
2. press + several times
3. release ON.

If characters still do not appear on the main display, follow the steps set out in “Resetting the calculator” below.

## Resetting the calculator

To reset the calculator:

1. Press and hold ON
2. Press and hold F3
3. Release both keys. The calculator should reset. If it does not:
   a. Insert the end of a metal paper clip into the hole in the back of the calculator. Insert the clip as far as it will go. Hold for one second and then remove the clip.
   b. Press ON.

If this does not fix the problem, the calculator requires a service.

In the event that the calculator contains a library with a bad configuration object, the calculator will re-boot repeatedly. If this happens, hold down the ◄ key to prevent the configuration object from running.

## Batteries

The HP 49G needs three AAA batteries to run. (Each AAA battery provides 1.5 volts.) To ensure optimum operation always use alkaline batteries, and always use batteries of the same brand and type.

Rechargeable batteries are *not* recommended because of their lower capacity and short low-battery warning time.

## When to replace the batteries

When battery power is low, the ((•)) annunciator is displayed. This annunciator remains displayed even when you turn the calculator off.

If the battery power is low when you turn the calculator on, the message `LowBat(S)` appears briefly on the screen.



## Replacing the batteries

You risk losing data if you:

- remove the batteries while the power is on
- press (ON) while replacing the batteries or
- leave the calculator without batteries for more than 2 minutes.

To change the batteries:

1. Turn the calculator off.
2. Remove the cover of the battery compartment. You do this by pressing down on the cover and sliding it away from the calculator.
3. Carefully remove the old batteries.
4. Immediately insert the new batteries.

The batteries must be oriented according to the outlines shown on the bottom of the battery compartment. Inserting batteries the wrong way may damage the calculator.

5. Replace the cover.
6. Press (ON) to turn the calculator on.

Always discard the old batteries according to the manufacturer's instructions.

# Calculator is not responding

If the HP 49G freezes and will not respond when you press CANCEL, its memory may have become corrupted. There are two ways to correct this:

1. halting the system
2. resetting the memory.

If your calculator has frozen, always try to fix the problem by halting the system. Only reset the memory if halting the system has not worked. Resetting the memory returns the calculator to its default state. All stored information, except for that stored in flash memory, will be lost.

## Halting the system

A system halt:

- cancels all system operations
- clears the history and the stack
- cancels all executing programs and initializes any local variables used in them
- turns off the user keyboard
- makes HOME the current directory.

### Halting the system from the keyboard

1. Press and hold ON.
2. Press F3.
3. Release both keys.

If the calculator is not responding to the keyboard, try the method outlined in the following section.

### Halting the system without using the keyboard

1. Insert the end of a metal paper clip into the hole in the back of the calculator. Insert the clip as far as it will go. Hold for one second and then remove the clip.
2. Press (ON).
3. If necessary:
   a. press and hold (ON)
   b. press and hold (F3)
   c. release both keys.

If this does not fix the problem, you will need to reset the memory (explained in the next section).

## Resetting the memory

Resetting the memory returns the calculator's memory to its default state. All variables, directories, and programs you have stored in the calculator will be lost, except for those that you stored in ports 1 (ERAM) and 2 (FLASH).

1. Press and hold down (ON) (F1) and (F6).
2. Continue to hold (ON) while releasing (F1) and (F6).
3. Release (ON).

# Calculator continually re-boots

A faulty or incompatible library can cause the calculator to re-boot continually. This can occur when you install a HP 48 series library that contains functions that are incompatible with the HP 49G.

1. Press and hold down (◄) (backspace key) until the calculator re-boots successfully.
2. Use File Manager to delete the faulty library from the port.

# Error on start up

If the message "Invalid Card Data" is displayed each time you turn the calculator on, you need to initialize the calculator's ports. This message is displayed if you attempted to recover memory when you turned the calculator on for the first time—see page 2-2—or if a port has become corrupted.

To initialize the calculator's ports:

1. Press CAT.
2. Highlight PINIT in the commands catalog.
3. Press ENTER or OK to place the command on the command line.
4. Press ENTER to run the command and initialize the ports.

# Low memory

The calculator's operations share memory with the objects you create. Therefore the calculator may operate slowly if memory is low.

The calculator displays messages as memory becomes critically low. These messages are discussed in the following three sections.

## No room for last stack

If there is not enough memory to save a copy of the current stack or history, `No room for last stack` is displayed when you press ENTER.

**Solution:** this is a warning message only. The calculator will complete its current operation, but the UNDO command will not be available. You should delete unwanted objects from the stack to prevent this condition continuing.

## Insufficient memory

`Insufficient memory` is displayed if there is not enough memory to complete an operation.

**Solutions**:

1. Try to do the calculation or operation in a way that would use less memory. (For example, use the factorial command instead of entering a string of consecutive integers each separated by the multiplication sign.)
2. Delete unwanted objects from history or from the stack.
3. Delete unwanted variables.

## Out of memory

`Out of memory` is displayed when the calculator runs completely out of user memory. In this state, the calculator is capable of only one operation: a one-by-one interactive purge. In this operation, you are asked if you want to purge—that is, delete—a series of objects, starting with the object on level 1 of the stack. If you agree—by pressing (F1)—you are then asked about the new level-1 object. This continues until either the stack is empty or you respond to a request to purge an object by pressing (F6) (for NO).

The calculator then asks if you want to delete other items. All together, the items you will be asked to purge are:

- the object on level 1 of the stack (repeated until there are no objects on the stack or until you press (F6) when asked to purge a particular stack object)
- the contents of LAST CMD
- the contents of LAST STACK (if active)
- the contents of LAST ARG (if active)
- the variable PICT (if present)
- user key assignments
- alarms
- the entire stack (unless already empty)
- each global variable.

After cycling through the list of purgeable objects, the calculator attempts to return to normal operation. If there is still not enough free memory, the purge process is repeated.

You can stop the purge process at any time by pressing CANCEL. You might do this after a while to check if the low-memory condition has been rectified. If sufficient memory is now available, the calculator returns to normal display; otherwise, the calculator beeps and continues with the purge process.

**In summary:**

- To delete the indicated object, press F1.
- To keep the indicated object, press F6.
- To stop the purge process, press CANCEL.

# Appendix E

# Working in RPN mode



## Contents



## Introduction

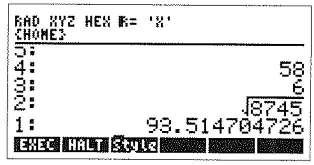
This appendix describes the RPN operating mode, and how to work with this mode. It also describes how to use the interactive stack commands to manipulate the objects on the stack.

RPN stands for Reverse Polish Notation. The main feature of this notation is that you specify operations after the numbers or objects to operate on. When you use the HP 49G in RPN mode, you have access to the stack. RPN mode, in conjunction with the stack, makes it easy to re-use the results of previous operations, and to perform chains of calculations.

# Using the stack

In order to perform operations in RPN mode, you place the object or objects on the stack, then apply the operation.

Entries on the stack are numbered (as in the example at the right). Each entry on the stack has an associated *level*. The level is the number of the line on which the entry appears. In the example at the right, 58 is on level 4, 6 is on level 3, $\sqrt{8745}$ is on level 2, and so on.




To set RPN mode, press (MODE) to access the Calculator Modes input form, and set the Operating mode option to RPN.

## Placing objects on the stack

You can create new objects and place them on the stack, or you can retrieve objects from memory and place them on the stack.

- To enter a number on the stack:
  a. Use the numeric keys to enter the number. The number appears on the command line.
  b. When you finish entering the number, press (ENTER). The number appears on level 1 of the stack.
- To enter an object that you create in an application, such as a matrix or an equation:
  a. Access Matrix Writer or Equation Writer.
  b. Create the matrix or the equation.
  c. Press (ENTER) to place it on level 1 of the stack.
- To retrieve an object from memory and place it on the stack:
  a. Press (VAR) to display the directories and variables in the current directory.
  b. Navigate to the directory that holds the object you want.
  c. Press the appropriate function key to select the object. It appears on level 1 of the stack.

When you add a new item to the stack, the existing items are pushed up a level. That is, the item at level 1 is pushed up to level 2, and the item at level 2 is pushed up to level 3 and so on.

## Performing RPN calculations

You use the command line and the stack to perform RPN calculations.

- When you use a command that takes only *one* argument, you can execute the command with the argument on the command line or the stack.
- When you use a command that requires multiple arguments—that is, a command that needs more than one object to act on—you place the arguments on the stack before you apply the command. You specify one argument per level, in the correct order. You can apply a multiple-argument command when the last argument is still on the command line.

A command's arguments are removed from the stack when the command is executed, and replaced by the result of the operation.

For example, to find the cube of 52, you need to specify two arguments: the number (52) and the index (3).

To perform the calculation, you enter:

52 ENTER 3 $y^x$

That is, you enter 52 onto the stack, and 3 is on the command line before you apply the operation. Since the $y^x$ operation requires two arguments, it uses the value on level 1 as the first argument, and the value on the command line as the second argument.

Alternatively, you can place 52 on stack level 2, and 3 on stack level 1 before you apply the $y^x$ operation. The operation uses the value on level 2 as the first argument, and the value on level 1 as the second argument.

Note that when you place all arguments on the stack before you apply a command, you can undo the command (by pressing ↱ UNDO), and return to the original stack.

For example, if you place both arguments on the stack before you apply the $y^x$ operation above, ↱ UNDO returns 52 on level 2 and 3 on level 1. If you apply the command with the last argument on the command line—that is, 52 ENTER 3 $y^x$—the ↱ UNDO operation returns only 52 on level 1.

Working in RPN mode

# Example stack calculations

## Using a one-argument command

1. If the argument is not already on level 1 of the stack, enter the argument onto the command line (and, optionally, onto the stack). If the argument is already on level 1 of the stack, go straight to step 2.
2. Execute the command.

**Example:** To calculate $\frac{1}{\sin 30}$

1. Enter 30 and press ENTER.
2. Press SIN.

   The result of sin 30 is now on level 1 of the stack. This result can be used as the argument of a further command without the result needing to be manually entered.
3. Press 1/x.

Note that if you get a symbolic answer when you wanted a numeric answer, press ↰ →NUM. The symbolic answer is evaluated.

## Using a multi-argument command

### Method 1

1. Enter the arguments, pressing ENTER after each one.
2. Execute the command.

**Example:** To calculate 23 × 97

1. Enter 23 and press ENTER.
2. Enter 97 and press ENTER.

   23 is now on level 2 of the stack and 97 is on level 1.


3. Press ×.

In this example, the order in which you enter the arguments does not affect the answer. However, this is not always the case with two-argument commands. In the cube example on page E-3, the result of entering the 3 before the 52 is the 3 raised to the power of 52, a very different result to 52 raised to the power of 3. Other examples where the order you enter the arguments is important include subtraction, division, and the percentage commands (%, %CH, and %T).

### Method 2

In method 1 above, each argument is entered onto its own level of the stack before the command is executed. Another way is to enter all the elements onto the command line separating each with a space. You can then either:

- press (ENTER) to place the arguments onto the stack and then execute your command or
- execute your command with the arguments still on the command line.

**Example:** To calculate $\sqrt[3]{531441}$

1. Enter 531441 (SPC) 3
2. Press (ENTER).
3. Press (↱)($\sqrt[x]{y}$).


Step 2 can be omitted if you will not want to undo the command and see the arguments. Pressing (↱)(UNDO) without having first placed the arguments on the stack deletes all record of the command: the result and the arguments. On the other hand, if you place the arguments on the stack before executing the command, pressing (↱)(UNDO) deletes the result but re-displays the arguments.

## Multi-command calculations

Because the result of a calculation is retained on the stack, you can easily perform complex calculations by accumulating the results of sub-calculations on the stack and then treating these results as the arguments in a further calculation.

**Example:** To calculate $13^2 - (17 \times 19) + \frac{3}{7}$

1. Enter 13(↰)($x^2$).

   The result—169—appears on level 1 of the stack.
2. Enter 17 and press (ENTER).
3. Enter 19 and press (ENTER).
4. Press (X).

   The product of 17 and 19—323—appears on level 1, and the previous result—169—is at level 2.

Working in RPN mode

5. Press [−].

   The two previous results—169—and 323—are now treated as the arguments in a further operation. This operation replaces the arguments with the result of the operation, that is, the difference between the first result and the second.

6. Press 3[ENTER]7[÷] to place the result of $\frac{3}{7}$ on level 1.

   If the calculator is in exact mode, the result appears as a fraction.

7. Press [+] to add this to the previous result.

   If the calculator is in exact mode, the answer is displayed as a number and a fraction. To display the approximate answer to 12 digit accuracy, press [↱][→NUM]

## Using computer algebra commands

**Example:** To substitute $x = y + 3$ in $x^2 + 3x + 7$

1. Use Equation Writer to create $x^2 + 3x + 7$ and press [ENTER] to place it on stack level 1.
2. Use Equation Writer to create the substitution, $x = y + 3$, and press [ENTER] to place it on stack level 1. This pushes the previous expression to stack level 2.
3. Press [↱][ALG] to access the Algebra command menu and select the SUBST command. The HP 49G performs the substitution and the result appears at stack level 1.

# Manipulating stack data

The HP 49G provides functions to manipulate the stack levels. To access these functions, you enter interactive stack mode.

- To enter interactive stack mode, press ▲.

  The interactive stack commands appear on the function key menu.

  a. Use the arrow keys to navigate up and down the stack to select the stack level that you want.

  b. Use the function keys to select the command that you want to apply to the current stack level.

- To exit interactive stack mode and return to normal stack operations:
  - press ENTER to apply the interactive stack command that you selected, or
  - press CANCEL to cancel the command.

When you enter interactive stack mode, data on the stack is displayed in text mode. For example, any equations on the stack are displayed in text mode rather than textbook mode.

## Interactive stack commands

| Command | Function |
|---|---|
| →LIST | Creates a list that contains the stack objects from 1 to the current level. The newly created list is placed on level 1 of the stack, and the original objects are removed. |
| DROPN | Deletes all levels below the selected level. |
| DUPN | Duplicates the levels from the currently selected level to level 1, and pushes up the existing levels to accommodate the duplicated levels. |
| ECHO | Press ECHO, then ENTER to copy the contents of the current level to the command line. Edit the contents on the command line, and press ENTER to place them on level 1 of the stack. |

Working in RPN mode

| Command | Function (Continued) |
|---|---|
| EDIT | Opens the contents of the current level in the most appropriate editor, ready for editing. For example, if the current level contains a matrix, the matrix opens in Matrix Writer. |
| GOTO | Prompts for a stack level to select, then selects the level number that you enter. |
| INFO | Displays information about the object at the current level, including its size in bytes. |
| KEEP | Deletes all levels above the selected level. |
| LEVEL | Copies the current level number to level 1 of the stack. |
| PICK | Copies the contents of the current level to stack level 1. All existing levels are pushed up one level. |
| ROLL | Moves the contents of the current level to level 1. The portion of the stack below the current level is rolled up to fill the space that is left. |
| ROLLD | Moves the contents of level 1 to the current level. The portion of the stack beneath the current level is rolled down to fill the space left by the item at level 1. |
| VIEW | Displays the contents of the current level in textbook mode. |

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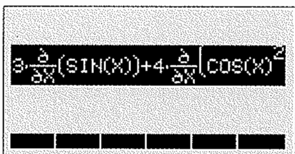


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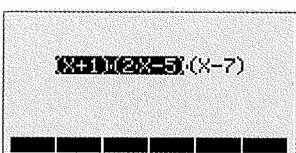


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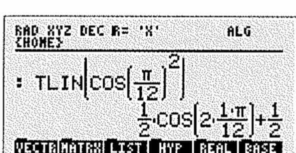


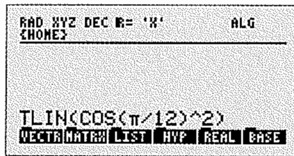


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