Getting Started with the HP 49 G Calculator: Basic Operations

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This document is intended to be an introduction to the HP49G calculator. Combined with other documents at InfoClearinghouse.com, it provides a survey of applications of the HP 49 G programmable/graphics calculator in science and engineering mathematics. The presentation of the calculator features and the exercises presented herein emphasize engineering applications in RPN mode. However, a few exercises in algebraic mode are also presented.

Notation

Keystrokes for the HP49 G keys are shown between brackets. For example, [ENTER] indicates the use of the ENTER key located at the lower right corner of the keyboard. Keystrokes that require either [↰], [↱], or [ALPHA], are followed by the appropriate instruction, which may not necessarily be the main key label. For example, the sequence [↰][UPDIR] indicates pressing the [↰] key, followed by the [VAR] key, which has the instruction UPDIR as a secondary label.

The keys at the top row of the keyboard, labeled F1 through F6, are referred to as *soft menu keys*. The operation of these keys will depend on the current content of the keys shown at the bottom of the display. Also, when using the soft menu keys, we will indicate the appropriate instruction between brackets. For example, to get to a specific subdirectory from the HOME directory, say E202, we will indicate that the key [E202] must be pressed. To find out which one of the white keys is the appropriate one, look at the labels associated with those keys at the bottom of the display.

For entering numbers or variable names, we could, for example, indicate the keystroke sequence, as in the instruction: ['][ALPHA][ALPHA][E][2][0][2][ALPHA], the keystroke sequence to enter in the display the variable name 'C303'. Or, we could simply indicate: press ['], and type C303.

The HP 49 G operating system or ROM

The HP 49 G is not like any other calculator. Think of it as a pocketsize computer. As with any computer, there is a Central Processing Unit (CPU) that is managed by an operating system. Unlike the HP 48 G, whose operating system is hardware-based -- and cannot be changed --, the operating system (ROM) of your HP 49 G can be upgraded by downloading new versions from the internet, or copying it from another HP 49 G. To obtain improved versions of the operating system check out the HP website:

http://www.hp.com/calculators/graphing/rom/

In that website, you will find instructions such as:

> Update your HP 49G
> Download a new ROM version to your calculator using the new
> *PC Connectivity Kit*. Or if you already have it get the ROM update (version
> 1.16). To view your ROM version type VERSION on the HP 49G.
>
> Beta ROM:
> *Version 1.17-5*

By clicking in the corresponding highlighted text, you can download the software required for your HP 49 G to communicate with your computer, or the most current version of the operating system (ROM). The information above corresponds to version *1.17-5 beta* of the HP 49 G ROM. *Beta* means simply that the version is still under development, and that should be used with caution. If you want to use a tested version

of the ROM, click on the *PC Connectivity Kit* text to get the current version. To communicate with a PC or Macintosh computer you need to have an appropriate cable, which can be purchased at many electronic stores directly or through the Internet. The software help feature has instructions for upgrading your ROM. Be warned, however, that upgrading the ROM requires about 30 minutes, so reserve plenty of time for such operation.

The ROM can also be loaded into a calculator from another calculator by using the command ROMUPLOAD in the receiving calculator. Instructions for ROM transfers between calculators are also available when you download the PC Connectivity Kit software. ROM transfer between calculators also takes about 30 minutes.

Keeping up to date with the HP 49 G

To keep up to date with the HP 49 G visit the following website regularly:

http://www.hp.com/calculators/graphing/49g_info.html

In that website you will find technical information about the calculator and other items of interest. Technical manuals for the calculator are available at the following website:

http://www.hp.com/calculators/graphing/49g_tech.html

Another way to keep up to date with new developments with the HP 49 G calculator, is to subscribe to, and check regularly, the discussion group *comp.sys.hp48*. Although it is called *hp48*, it is the forum for discussion, report of bugs, questions and answers about both the HP 48 G and the HP 49 G calculators. It may occur that, in the future, a new group (perhaps called comp.sys.hp49) will be created, but *comp.sys.hp48* is the group to visit at this time.

Programs for the HP 49 G

As you know, your calculator is not only a traditional scientific/graphic calculator. It is also programmable. That means that you can develop your own routines that perform certain numerical and logical operations of your choice. Many people around the world develop programs for the HP 49 G and make them available, most of them for free, to users with access to the Internet. There is a number of websites were such programs are available. You can find them by doing an Internet search with your web browser. One of the best collection of programs for the HP 48 G and HP 49 G is, however, found under the URL:

http://www.hpcalc.org

(If that URL doesn't work, try the alternative address: http://165.234.32.14)

This website was, of course, developed for the HP 48 G and earlier HP calculators. Therefore, most of the links you will find are related to the HP 48 G. There is a number of them related to the HP 49 G that permits you to download programs in a variety of categories such as math, statistics, engineering, etc.

There are two programs that I have found to be very useful for my applications (mainly civil and environmental engineering, mathematics, and statistics): *Solvesys*, a library that allows you to solve a number of non-linear equations simultaneously (also available at: http://solvesys.cjb.net/); and, *LibMaker*, a program that allows you to create libraries out of your own directories in the calculator.

Some HP 49 G programming concepts

This section is intended to clarify some concepts about programs in the HP 49 G calculators. A *program* in the HP 49 G calculator, is simply a collection of commands stored in a variable name that are performed whenever that variable name is invoked. A *programmed command* can be invoked directly from the keyboard, or by listing it in another program.

Programming Languages

There are several ways that a program can be created. The simplest is to use the calculator keyboard to create the program in User RPL language. *RPL* is the name of the programming language native to the HP 48/49 G calculators. The *User RPL* language is a subset of the RPL language which is relatively easy to access from the keyboard, and, with some experience, relatively easy to program. There exists another subset of RPL, called *System RPL*, which is more cryptic and requires a longer learning curve to master. System RPL produces programs that optimize use of memory and time resources in the calculator. Programs can also be created for the HP 49 G calculator by using *Assembler* languages. Assembler language is just one level above the binary language (machine language) used by computers. Programming in Assembler language requires developing the program in a computer and then downloading it into the calculator. Software exists that lets the user program an HP 48 G or HP 49 G calculator in User RPL or System RPL in a computer. In algebraic mode it is possible to program the HP 49 G using a language called HP Basic.

Libraries

There is a type of program called a *library* that can be loaded and installed in your calculator and is accessible by using the [↱][LIB] keystroke sequence. Libraries reside in *memory ports*, of which your HP 49 G calculator has three: ports 0, 1, and 2. Ports are visible by using the same keystroke sequence used to access libraries (You may need to press [NXT] to get to the listing of ports if you have three or more libraries active in your calculator). Programs defined in libraries are available to the user regardless of the current working directory. That makes library programs very accessible and convenient. Also, library programs cannot be modified, so there is very little risk that you will accidentally erase or modify a library. The program *LibMaker*, mentioned above, allows you to create your own libraries after you have created User RPL programs in a given sub-directory within your calculator. More details about creating and using libraries will be provided later.

Calculator operating modes

Most HP calculators, particularly those for engineering applications, use what is referred to as *the Reverse Polish Notation* (*RPN*) mode. Most other calculators use an *algebraic entry mode*, which mimics the way that we write arithmetic or algebraic expressions in paper. The RPN mode is more efficient in the use of calculator memory and processing time, and became very well known and widely used in the engineering community when adopted by HP back in the 1970's. The HP 49 G allows you to choose between both RPN and algebraic entry modes. I prefer to use the RPN mode not only because I am more familiar with it from my experience with the HP 48 G, but also because, by using the RPN mode, one can use many of the existing expertise from the HP 48 G.

Changing the calculator mode

To change the calculator mode, press the [MODE] key in the calculator. If you haven't changed your default, you will have in the calculator an input screen, labeled CALCULATOR MODES, with the first line indicating the Operating Mode as *Algebraic*. To change mode to *RPN*, toggle the [+/-] button until RPN is shown, or use the [CHOOS] soft key and select RPN. Press [OK] to return to normal calculator operation. A similar process is used to change the operating mode to algebraic. For the time being, keep the operating mode in the *algebraic* option.

Comparing algebraic mode with RPN mode

The following program illustrates a calculation performed using both the algebraic and RPN modes. The arithmetic expression to calculate is:

$$\sqrt{\frac{3\cdot(5-\frac{1}{3\cdot 3})}{23^3}+\exp(2.5)}$$

To enter this expression in the calculator we can use the *equation writer* as follows:

[EQW] [√x] [3] [×] [↰][( )] [5] [-] [1] [÷] [3] [×][3] [▲][▲][▲][▲][▲][▲]

[÷] [2] [3] [y^x] [3] [▶][▶] [+] [↰] [e^x] [2] [.] [5] [ENTER]

After pressing [ENTER] the calculator displays the expression:

√ (3*(5-1/(3*3))/(23^3+EXP(2.5))

Pressing [ENTER] again will provide the following value (accept Approx. mode on, if asked, by pressing [OK]):

3.49051563628

You could also type the expression directly into the display without using the equation writer as follows:

[√x] [↰][( )] [3] [×] [↰][( )] [5] [-] [1] [÷] [3] [×][3] [▶][÷] [2] [3] [y^x] [+] [↰] [e^x] [2] [.] [5] [ENTER]

to obtain the same result.

Let's try now the same operation in reverse polish notation (RPN). First, clear the screen by using

[↱] [CLEAR].

Then, change the operating mode to RPN by following the procedure indicated above. Notice that in RPN operating mode, the display shows several levels of output labeled, from bottom to top, as 1, 2, 3, etc. This is referred to as the *stack* of the calculator. The different levels are referred to as the *stack levels*, i.e., stack level 1, stack level 2, etc. Another way to refer to the first three stack levels is to use the names *register x* for stack level 1, *register y* for stack level 2, *register z* for stack level 3, and *register t* for stack level 4. Informally, these four registers are referred to simply as *x*, *y*, *z*, and *t*.

Basically, what RPN means is that, instead of writing an operation such as

$$3 + 2,$$

as

[3][+][2][ENTER],

we write first the operands, in the proper order, and then the operator, i.e.,

[3] [ENTER] [2] [ENTER] [+].

As you enter the operands, they occupy different stack levels. Entering [3][ENTER] puts the number 3 in stack level 1 (register x). Next, entering [2][ENTER] pushes the 3 upwards to occupy stack level 2 (register y). Finally, by pressing [+], we are telling the calculator to apply the operator, or program, [+] to the objects occupying registers y and x. The result, 5, is then placed in register x.

Let's try some other simple operations before trying the more complicated expression used earlier for the algebraic operating mode:

35×2	[3][5] [ENTER] [2] [×]
123/32	[1][2][3] [ENTER] [3][2] [÷]
4^2	[2] [ENTER] [2] [y^x]
$\sqrt[3]{27}$	[2][7] [ENTER] [3] [↱][$\sqrt[x]{y}$]

Notice the position of the y and the x in the last two operations. The base in the exponential operation is y (stack level 2) while the exponent is x (stack level 1) before the key [y^x] is pressed. Similarly, in the cubic root operation, y (stack level 2) is the quantity under the root sign, and x (stack level 1) is the root.

Try the following exercises:

$(5 + 3) \times 2$	[5][ENTER] [3][ENTER]	Calculates (5 +3) first.
	[2] [×]	Completes the calculation.

Let's try now,

$$\sqrt{\frac{3\cdot(5-\frac{1}{3\cdot 3})}{23^3}+\exp(2.5)}$$

[3][ENTER]	Enter 3 in x
[5][ENTER]	Enter 5 in x, 3 moves to y
[3][ENTER]	Enter 3 in x, 5 moves to y, 3 moves to z
[3][×]	Place 3 and multiply, 9 appears in x
[1/x]	Calculate 1/(3×3) = 1/9 = .111111, last value placed in x; 5 in y; 3 in z
[-]	Calculate 5 - 1/(3×3) = 4.888888, which occupies x now; 3 in y
[×]	Calculate 3× (5 - 1/(3×3)) = 14.66666, this value appears in x now.
[2][3][ENTER]	Enter 23 in x, 14.66666 moves to y.
[3] [y^x]	Enter 3, calculate 23^3 = 12167, this value appears in x now. 14.66666 in y.
[÷]	Calculate (3× (5 - 1/(3×3)))/23^3 = 1.205×10^{-3}, this value now appears in x (*).
[2][.][5] [↰] [e^x]	Calculate $e^{2.5}$ = 12.18249, this value appears in x, y shows previous value.

[+] Calculate $(3\times (5 - 1/(3\times 3)))/23^3 + e^{2.5} = 12.18369$, this value appears in x.
[√x] Calculate $\sqrt{((3\times (5 - 1/(3\times 3)))/23^3 + e^{2.5})} = 3.4905156$, this value appears in x.

Obviously, the algebraic mode is easier to use for completing this calculation. However, even when in the RPN mode you can still use the Equation Writer to write algebraic expressions. Thus, the same steps used earlier to write the expression with the Equation Writer in algebraic mode, can be used in the RPN mode as follows:

[EQW] [√x] [3] [×] [↰][( )] [5] [-] [1] [÷] [3] [×][3] [▲][▲][▲][▲][▲][▲][▲]
[÷] [2] [3] [y^x] [3] [▶][▶] [+] [↰] [e^x] [2] [.] [5] [ENTER]

The resulting expression is shown in stack level 1 (register x). Pressing [ENTER] again, however, will not calculate the numerical result of the expression. It will simply enter a copy of the expression in register x, pushing the original expression to register y. This operation is useful if you want to preserve an intact copy of any expression for future use. To obtain a numeric value press [↱][EVAL] ([SYMB] key) or [↱][→NUM] ([ENTER] key).

Note: My personal bias towards the RPN mode will require you to use that calculator mode in most of the applications that follow. Therefore, make sure that your calculator is set to RPN mode by pressing [MODE] and toggling the [+/-] key until RPN shows in the *Operating Mode*.. field. Press [OK] to return to normal calculator display.

Flags

A flag is a variable or object that specifies a given setting of the calculator or an option in a program. Flags in the HP 49 G calculator are labeled with numbers. Flags that are used to control the process in a user-defined program are called *user flags*, and referred to by using positive integer numbers. Flags used to control calculator settings, i.e., *system flags*, are labeled with negative integer numbers.

To see the current flag setting press the [MODE] button, and then the [FLAGS] soft key (i.e., F1). You will get a screen labeled *SYSTEM FLAGS* listing flag numbers and the corresponding setting. (Note: in this screen the system flag labels use positive integer numbers. Negative integer numbers are used in the stack or in programs to set or clear system flags). A flag is said to be *set* if you see a check mark (✓) in front of the flag number. Otherwise, the flag is *not set* or *cleared*. To change the status of a system flag press the soft key [✓CHECK] while the flag you want to change is highlighted. You can use the vertical arrow keys to move about the list of system flags.

Example of flag setting: general solutions vs. principal value

For example, the default value for system flag 01 is *General solutions*. What this means is that if an equation has multiple solutions, all the solutions will be returned by the calculator, most likely in a list. By pressing the [✓CHECK] soft key you can change system flag 01 to *Principal value*. This setting will force the calculator to provide a single value known as the principal value of the solution.

To see this at work, first clear system flag 01 (i.e., set it to *General solutions*). Press [OK] twice to return to normal calculator display. We will try a quadratic equation solution. Say, solve

$$t^2-3t+5 = 0.$$

Use the following keystrokes:

[EQW] [alpha][↰][T] [y^x][2] [▶] [-] [3] [×] [alpha][↰][T] [+] [5] [▲][▲] [↱][=] [0] [ENTER]
[ENTER] (To keep a second copy of the equation)

[↦] [‘] [alpha][↰][T] [ENTER]
[alpha][alpha] [Q][U][A][D] [ENTER]

The solution is given as a list: `{t = (1.5,-1.65831239▶`

To see the two solutions press [▼]. The complete list of solutions is:

`{‘t = (1.5,-1.65831239518)’ ‘t = (1.5,1.65831239518)’}`

Press [ENTER] to return to normal calculator display. Press [⇦] to clear the stack.

Now, let’s change the setting of system flag 01 to *Principal value* by using:

[0][1][+/-] [ENTER] [alpha][alpha] [S][F] [ENTER] (This produces no output)

Solve for the equation once more using:

[↦] [‘] [ALPHA][↰][T] [ENTER]
[ALPHA][ALPHA] [Q][U][A][D] [ENTER]

The solution is now: `{t = (1.5,1.65831239▶`

Press [▼] to see a unique solution (the principal value):

`t = (1.5,1.65831239518)`

Press [ENTER] to return to normal calculator display. Press [⇦] to clear the stack.

***Notes*:**
[1] For a quadratic equation of the form $ax^2+bx+c = 0$, the two general solutions are given by

$$x = (-b/2a) \pm [(b/2a)^2+c]^{1/2}.$$

while the principal value would use only the positive sign in front of the square root.

[2] A result which include an ordered or the form (*a*,*b*), such as those shown above for *t*, represents a *complex number*. Typically, complex numbers are represented as $a+bi$, where i is the unit imaginary number defined as $i^2 = -1$.

Other flags of interest

Bring up once more the current flag setting by pressing the [MODE] button, and then the [FLAGS] soft key. Make sure to clear system flag 01 if it was left set from the previous exercise. Use the up and down arrow keys to move about the system flag list.

Some flags of interest and their preferred value for the purpose of the exercises that follow in this manual are:

02 Constant → symb:	Constant values are kept as symbols
03 Function → symb:	Functions are not automatically evaluated, instead they are loaded as symbolic expressions.
*27 ‘X+Y*i’ →(X,Y):*	Complex numbers are represented as ordered pairs
60 [α][α] locks:	The sequence [alpha][alpha] locks the alphabetic keyboard
91 MTRW: Matrix:	The matrix writer produces a matrix, i.e., [[a_{11} a_{12} a_{13}]…], rather than a list of lists, {{a_{11}, a_{12}, a_{13}},…}.

Press [OK] twice to return to normal calculator display.

Objects and their types in the HP 49 G calculator

Your calculator is accompanied by a small booklet called *The HP 49 G Pocket Guide*. It can be used as a quick reference for figuring out the operation of calculator commands. It will be very handy once you have enough experience to understand the operation of the most commonly used commands. At this point I want to use it to show you all the types of objects that you can operate with in your calculator. Open your Pocket Guide to the very last page, page 80, to see a list of object types. The table shows 31 different types of objects, with their corresponding type number, name, and an example to illustrate the concept. Some of the most useful type of objects are listed below.

- For most real-number arithmetic operations you need only object type 0, *real numbers*.
- *Complex numbers*, object type 1, are an extension of real numbers that include the unit imaginary number, $i = \sqrt{(-1)}$. A complex number, e.g., $3 + 2i$, is written as *(3, 2)* in the HP 49 G calculator.
- Vector and matrix operations utilize objects of type 3, *real arrays*, and, if needed, type 4, *complex arrays*. Objects type 2, *strings*, are simply lines of text (enclosed between quotes) produced with the alphanumeric keyboard.
- A *list* is just a collection of objects enclosed between curly brackets and separated by spaces in RPN mode (the space key is labeled [SPC]), or by commas in algebraic mode. Lists, objects of type 5, can be very useful when processing collections of numbers. For example, the columns of a table can be entered as lists. If preferred, a table can be entered as a matrix or array.
- Objects type 8 are *programs in User RPL language*. These are simply sets of instructions enclosed between the symbols << >>.
- Associated with programs are objects types 6 and 7, *Global* and *Local Names*, respectively. These names, or variables, are used to store any type of objects. The concept of *global* or *local* names is related to the scope or reach of the variable in a given program.
- An *algebraic object*, or simply, an *algebraic* (object of type 9), is a valid algebraic expression enclosed between apostrophes.
- *Binary integers*, objects of type 10, are used in some computer science applications.
- *Graphics objects*, objects of type 11, store graphics produced by the calculator.
- *Tagged objects*, objects of type 12, are used in the output of many programs to identify results. For example, in the tagged object: Mean: 23.2, the word Mean: is the tag used to identify the number 23.2 as the mean of a sample, for example.
- *Unit objects*, objects of type 13, are numerical values with a physical unit attached to them.
- *Directories*, objects of type 15, are memory locations used to organize your variables in a similar fashion as folders are used in a personal computer.
- *Libraries*, objects of type 16, as mentioned earlier, are programs residing in memory ports that are accessible within any directory (or sub-directory) in your calculator. They resemble *built-in functions*, objects of type 18, and *built-in commands*, objects of type 19, in the way they are used.

Organizing data in your calculator

Data can be organized in directories and sub-directories in a similar fashion as folders are used to organize data in a computer. When you turn on your calculator, you will see the characters {HOME} listed above the horizontal line at the top of the display. The name between curly brackets is the *path* of the working directory. When you use your calculator for the very first time there will be no sub-directories in the HOME directory. The labels above the soft menu keys will most likely list some variables corresponding to the Calculator Algebraic System or CAS, such as the default unknown variable VX, and others called REALA, PERIO, etc., if anything at all. To see the contents of any variable listed in the soft menu keys, press the key, or press the red [↱] key followed by the corresponding soft menu key.

To create directories, you will need to type the directory name in stack level 1, and use the command CRDIR. For example, suppose you want to create a directory named DIR1 under your HOME directory. Use the following:

[ALPHA][ALPHA]	This locks the alphabetic keyboard
[D][I][R][1] [ENTER]	Enter name. The [ENTER] key disengages the alphabetic keyboard in this instance.
[↰][PRG][MEM][DIR][CRDIR]	Navigates through menus to activate the CRDIR (Create DIRectory) command
[VAR]	Recovers the variables menu.

You should have at this point the label [DIR1] associated with the first of your soft menu keys. Notice that the label has the form of a folder, indicating that DIR1 is a directory within the HOME directory.

To get inside the DIR1 directory, press the corresponding soft menu key. The path specification at the top of the display will now show the path {HOME DIR1}. (This is similar to having the path C:\HOME\DIR1 in a PC computer.) Of course, there will be no variables stored within this directory and all the soft menu keys will be empty.

You can store any kind of objects in variables within the HOME directory or any subdirectory you create. For example, within the directory DIR1 you can create a couple of variables as follows:

1) Store the value of 324.5 into a variable that we will call A:
   [3][2][4][.][5][ENTER] [ALPHA][A] [STO>]

2) Store the string "MY DIRECTORY" in variable TITLE:
   [↱][""][ALPHA][ALPHA] [M][Y][SPC][D][I][R][E][C][T][O][R][Y][ENTER]
   [ALPHA][ALPHA] [T][I][T][L][E][ENTER] [STO>]

The soft menu keys will show the labels [TITLE] and [A] corresponding to the variables of the same name.

By creating directories and sub-directories within the HOME directory, you can develop your own directory tree to store any number of variables, algebraic objects, programs, etc. To move down the directory tree just press the soft menu key corresponding to the directory you want to access. To move up the directory tree use the command UPDIR, accessible through [↰][UPDIR].

You can visualize this tree structure by using: [↰][FILES]. This will show a window titled FILE MANAGER showing the following information:

```
0: IRAM          234KB
1: ERAM          254KB
2:FLASH         1080KB
Home             234KB
Etc.
```


The first three lines represent the memory ports where program libraries are stored. Line 4 and subsequent is the picture of your directory tree, with the HOME directory as the trunk of the tree. You can move through the directory tree by using the arrow keys. To access any particular directory or sub-directory, just highlight its name and press [OK]. The resulting screen will list all the variables in your directory or sub-directory indicating their type and size in KB. To access the normal calculator display within the selected directory or sub-directory, press [NXT][NXT][HALT]. To recover the soft menu keys, press [VAR].

More details on the use of variables and the FILES command can be found in the calculator's manual.

Note: Use the [VAR] key anytime to recover the listing of your variables in the soft key menu at the bottom of the calculator display.

The HP 49 G keyboard

In the previous examples we have already used many of the keys in the calculator's keyboard. In this section we explore the keyboard in more detail.

The HP 49 G keyboard consists of 51keys, most of them organized in five columns, except for the four arrow keys near the upper right corner of the keyboard, and the six soft menu keys (or soft keys) at the top of the keyboard. Each key in the keyboard can access more than one object or operation by combining it with the alphabetic key [ALPHA], the blue left-shift key [↰], and the red right-shift key [↱]. Additional characters are accessible by combining [ALPHA][↰] and [ALPHA][↰] with some of the keys.

Primary function of each key

The primary, or main, function of each key is shown as a white label on the key. For example, the main function of the green [ALPHA] key is to access the alphabetical keyboard. Similarly, the main function of the [√x] key is to extract the square root of the value in register x.

Alphabetic characters

The gray keys also show a white, uppercase letter in green background, indicating the upper-case alphabetic character that can be placed in the display by pressing that key after the [ALPHA] key. Alphabetic characters are also available in the six soft menu keys at the top of the keyboard.

Notice that the key corresponding to the letter X, also has a main function to enter the letter X. The letter X occupies a special place in the algebraic, calculus, and graphical operations of the calculator, being the default name of the variable used for those operations. In other words, as in mathematical textbooks *x* is the default unknown variable, *X is the default unknown variable in the HP 49 G calculator*. To verify this, check that there is a variable in your calculator called VX in your HOME directory. Press the corresponding soft menu key to verify that it contains the value 'X'.

Left-shift and right-shift functions

Most keys have a third function associated with them and activated by pressing the blue left-shift key [↰]. The left-shift function associated with each key is shown above the key towards the left in blue color. For example, the left-shift function associated with the [SIN] key is the ASIN function (arcsine). The fourth function of a key is associated with the red right-shift key [↱]. This function is shown above and to the right of each key in red color. The right-shift function associated with the [SIN] key, for example, is summation symbol Σ.

Secondary functions of the soft menu (F1-F6) keys

As indicated earlier, the soft menu keys are used to access the objects corresponding to the current menu as displayed below stack level 1 in RPN mode. They also have the alphabetic characters A, B, C, D, E, and F, associated with them. Notice that right above the soft menu keys there are blue labels corresponding to the *graphic functions* Y=, WIN, GRAPH, 2D/3D, TBLSET, and TABLE. Warning: *These functions are only accessible, by pressing [↰] followed by the corresponding soft menu key, when the calculator is operating in algebraic mode. In RPN mode, pressing [↰] followed by any particular soft menu key, will store the contents of register x into the variable corresponding to the soft menu key*. Therefore, make sure not to use the left-shift (blue label) functions associated with the soft menu keys (F1-F6) when in RPN mode. You can still access the graphic commands in the soft keys *in RPN mode* by holding down the left-shift key [↰] while pressing the desired soft menu key.

The arrow keys

The arrow keys allow the user to move the cursor within the display in the four main directions: up, down, left, and right. Combining these keys with the blue left-shift key will move the cursor to the first or last line (up or down) in a list, or to the first or last character in a line (left or right) within the visible window of the display. Using the red right-shift key before pressing any of the arrow keys will move the cursor to the absolute first or absolute last line in a list, or to the absolute first or absolute last character of a line, even if those positions are not visible in the display.

Utility keys

The six keys located in two rows to the left of the oddly shaped arrow keys, and the row immediately below, can be referred to as utility keys. They allow the user access to many basic utilities of the calculator. Let's discuss them in detail:

[APPS] Produces a CHOOSE box listing a number of function menus including plot, input/output, library of constants, numeric solver, time & date, equation writer, and file manager. Many of these menus were accessible through keys in the HP 48 G calculator.

[←][FILES] Provides access to the file manager (see above for some more information).

[→][BEGIN] This right-shift function is used to mark the beginning character of a segment of an object that will be highlighted or selected for copying or replacing. This is therefore, an editing function.

[MODE] Used to modify different settings in the calculator. We have used this key to change the operating mode from algebraic to RPN, and vice versa. Other options that can be changed include: number format, angle measure, and coordinate system. Using the [CHOOS] soft menu key when the appropriate option is highlighted, will show the different settings available for that option (e.g., Degrees, Radians, Grads, for the angle measure). Other options, which can be changed by using the [CHK] soft menu key, are: sound a beep when mistakes are made, provide a 'key click' sound, and recover last stack.

Within this screen you can also access other options for which different settings can be selected. These options are accessed by pressing the soft menu keys [FLAGS], [CAS], or [DISP]. The [CANCL] soft menu key cancels the last selection and returns you to normal calculator display. The [OK] key, saves any change made to the MODE options, and returns you to normal calculator display.

 The [FLAGS] command permits the user access to a list of 120 System Flags. These "flags" are system variables that determine options such as whether an underflow calculation should be force to become zero, or should show an error message. Use the up and down arrow keys to navigate through the list of system flags. Any system flag showing a check mark to the left of its ID number has had its default changed to the alternative setting. You can change a system flag setting by using the [CHK] soft menu key. Press [OK] to leave the FLAGS environment.

 The [CAS] command accesses the Calculator Algebraic System settings. Some of these settings include the default independent variable ('X' is the original setting), a modulo parameter (see manual), and options for numeric values versus constant names (e.g., e, i, π) , approximated (e.g., 0.5) versus

exact (e.g. 1/2) values, complex results allowed in some functions, verbose messages for calculus information, step-by-step algebraic and calculus manipulation of some expressions, increasing versus decreasing power for polynomial ordering, rigorous results (whether to simplify |x| to x), simplify or not non-rational expressions. Use the [CHK] key to change any of these settings, [CANCL] to cancel any changes in settings and return to the MODE environment, [OK] to save changes and return to the MODE environment.

- The [DISP] command access a screen where you can make changes to settings controlling the calculator display. You can change the system font, change options for editing, for the display of expressions in the stack, and for the equation writer (EQW). You can change the number of lines in the header in the display, select whether to show the current time in the display, and whether you want a digital or analog clock for the latter. [CANCL] and [OK] soft menu keys are available in this screen to cancel or accept any change in the display settings.

[←][CUSTOM] Provides access to a customized keyboard. In other words, you can re-define the keyboard operation and access the customized keyboard through this operation. For more details consult the calculator manual.

[→][END] This right-shift function is used to mark the ending character of a segment of an object that will be highlighted or selected for copying or replacing. This is also an editing function.

[TOOL] Provides a soft menu with a number of editing operations and operations on variables. The commands available are:

- [EDIT] Used to edit the contents of register x.
- [VIEW] Displays contents of register x in full screen.
- [RCL] Recalls contents of variable the variable whose name is in register x.
- [PURGE] Deletes the variable whose name is listed in register x. If a list of variables is placed in register x, the entire list of variables is purged with this command. The [PURGE] command does not work with directory names.
- [CLEAR] Clears the stack.
- [STACK] Provides a menu of stack operations:

  [DUP][SWAP][OVER][ROT][UNROT].

  Pressing [NXT] access the following operations within the STACK menu:

  [ROLL][ROLLD][PICK][UNPIC][PICK3][DEPTH].

  Pressing [NXT] once more produces:

  [DUP2][DUPN][DROP2][DROPN][DUPDU][NIP].

  Pressing [NXT] once more produces the menu:

  [NDUPN][ ][ ][ ][ ][PRG].

  Of all the STACK operations listed, you most likely be using regularly the operations [DUP] and [SWAP]:

- [DUP]: Duplicates the content of register x into register y.

[SWAP]: Swaps the contents of registers x and y.

The [PRG] command is the same as the keystroke combination [↰][PRG].

[↰][*i*] Places the complex unit, *i*, in the display. If the complex mode is not activated, you will be asked if you want it activated. If you say NO, then no action takes place. If you say YES, either the symbol *i* or the value (0., 1.) is placed in register x.

[↱][|] The vertical bar | is used to indicate an evaluation, as in $(x^2 + 1)|_{x=2}$. To use this function you need to have an algebraic expression in register y, and a list of variables and values in register x. Try this example:

[EQW][X][y^x][2][▶][+][1][ENTER] [↰][{}][X] [SPC] [2] [ENTER] [↱][|][ENTER]

The result is $2.^2+1$.

[VAR] Shows the names of variables in your working directory as labels associated with the soft menu keys.

[↰][UPDIR] Moves to the directory immediately above the working directory. Repeated applications this command will eventually land you in the HOME directory.

[↱][COPY] Copies highlighted characters within an object into a temporary storage (*the clipboard*). This is another editing command.

[STO▶] Stores object in register y into variable whose name is listed in register x.

[↰][RCL] Recalls contents of variable whose name is listed in register x.

[↱][CUT] Cuts highlighted characters within an object. This is yet another editing command.

[NXT] Because there are only six soft menu keys, only six commands or variable names can be seen at a time. The [NXT] command allows the user to move to the next set of six commands or variable names, and so on, until all commands or variable names have been shown.

[↰] [PRV] Shows the previous set of six commands or variable names, if any, in the current menu or directory.

[↱] [PASTE] Pastes characters in the clipboard into the location in an object indicated by the cursor's position. This is yet another editing command.

[HIST] Provides a list of the most recent commands, i.e., a history of calculator usage.

[↰][CMD] Shows a list of the last four commands used in the calculator. You can re-use any of those four commands by highlighting it and pressing [OK].

[↱][UNDO] Cancels last stack operation.

[CAT] Provides a list, or catalog, of all commands available in the calculator. Command names shown in italics corresponds to user-loaded libraries. To access a particular command, press [ALPHA] followed by the first letter of the command. Then, use the up and down arrow keys to highlight the desired command. Press [OK] to activate the command. You can also enter more than the first letter in a command by using [ALPHA][ALPHA] followed by the few first letters of the command. Press [ALPHA] when you're done, before pressing [OK] to activate the command.

[←][PRG] Use it to access programming menus.

[→][CHARS] Provides access to all the alphanumeric characters available in the HP 49 G. Use the arrow keys to navigate across and down the list of characters. As you highlight any particular character, the keystroke sequence that you can use to generate such character directly from the keyboard will be shown in the lower left corner of the display. If no keystroke sequence is available, the lower left corner of the display will be blank. To copy a given character directly from the list, highlight the desired character and press the soft menu key labeled [ECHO1]. To copy more than one character at a time, select the characters desired one by one, pressing [ECHO] for each one of them. When finished selecting characters, press [ENTER]. The character or set of characters "echoed" to the display will show up at the bottom of the display as a character string. Pressing [ENTER] will convert the characters to an algebraic expression that will be placed in register x.

[EQW] Starts the equation writer.

[← [MTWR] Starts the matrix writer.

[→]['] Places a set of apostrophes in the display leaving the cursor ready for typing an algebraic expression between them.

[SYMB] Lets the user access a number of menus for symbolic operations:

[ALG]	for algebraic manipulation.
[ARITH]	for arithmetic manipulation.
[CALC]	for calculus operations.
[GRAPH]	for graphical operations.
[SOLVE]	for solution of equations and differential equations.
[TRIG]	for manipulating trigonometric expressions.
[NXT][EXPLN]	for manipulating expressions involving natural logarithms and exponential functions.

These menus and the operations they contain are discussed elsewhere.

[←][MTH] Lets the user access a number of menus for mathematics operations (same as the [MTH] key in the HP 48 G):

[VECTR]	for vector operations.
[MATRX]	for matrix operations.
[LIST]	for operations with lists.
[HYP]	for hyperbolic functions.
[REAL]	standard functions that apply to real numbers (e.g., absolute value).
[BASE]	for conversions between decimal, binary, octal, and hexadecimal number bases.

[NXT][PROB]	for functions involving probability calculations.
[FFT]	for Fast Fourier Transform and inverse applications.
[CMPLX]	standard functions that apply to complex numbers (e.g., conjugate).
[CONST]	access to the list of constants, such as π, *i*, e, available in the calculator.

[↦][EVAL] Evaluates expression in register x. The result of the evaluation depends on the type of expression in stack level 1. For example, pressing [EVAL] when a list of objects is in register x will decompose the list showing the objects in the different levels of the display, with the first object in the topmost level of display necessary. Most algebraic expressions will be simplified, and numerical results provided when pressing [EVAL].

[⇦] Drops contents of register x, letting every display level move one level downwards.

[↤][DEL] Deletes contents from all levels of the display (practically the same as [↦][CLEAR]).

[↦][CLEAR] Clears display (practically the same as [↤][DEL]).

Mathematical operations keys

The operation of the next two rows of keys should be obvious from the labeling of the keys. These could qualified as mathematical operations keys. Here is a quick run down of their operation:

[y^x] Calculates the x power (stack level 1) of the value in register y.

[↤][e^x] Calculates the exponential function of the value in register x.

[↦][LN] Calculates the natural logarithm (logarithm base *e*) of the value in register x.

[$\sqrt{x}$] Calculates the square root of the value in register x.

[↤][x^2] Calculates the square of the value in register x.

[↦][$\sqrt[y]{x}$] Calculates the y-th root of the value in register x.

[SIN] Calculates the sine of the value in register x.

[↤][ASIN] Calculates the sine inverse function of the value in register x.

[↦][Σ] In the Equation Writer or in an algebraic expression in stack level 1, this keystroke combination provides the summation symbol.

[COS] Calculates the cosine of the value in register x.

[↤][ACOS] Calculates the cosine inverse function of the value in register x.

[↦][∂] In the Equation Writer or in an algebraic expression in stack level 1, this keystroke combination provides the derivative symbol. If an algebraic expression is provided in

register y, and a variable in register x, this keystroke combination will calculate the derivative of the expression in y with respect to the variable in x.

[TAN] Calculates the tangent of the value in register x.

[←][ATAN] Calculates the tangent inverse function of the value in register x.

[→][∫] In the Equation Writer or in an algebraic expression in stack level 1, this keystroke combination provides the integration symbol. You can calculate an integral by using this keystroke sequence provided you have the variable of integration in register x, the expression to be integrated in register y, the upper limit of integration in register z, and the lower limit of integration in register t.

[EEX] this key is used to enter powers of ten in the calculator. A number such as -32.345×10^{-23}, is entered into the HP 49 G calculator as

[3][2][.][3][4][5][+/-][EEX][2][3][+/-] [ENTER],

and displayed as `-3.2345E-22`

[←][10^x] Calculates the antilogarithm of the value in register x.

[→][LOG] Calculates the base-10 logarithm of the value in register x.

[+/-] Entered after a number will change the sign of that number. Used while in a choose box, will toggle through the different options.

[←][≠] Enters the "not equal" sign.

[→][=] Enters the "equal" sign.

[X] Enters the letter X.

[←][≤] Enters the "less than or equal" sign.

[→][<] Enters the "less than" sign.

[1/x] Calculates the inverse of the value in register x.

[←][≥] Enters the "greater than or equal" sign.

[→][>] Enters the "greater than" sign.

[÷] Divides the contents of the y register by those of the x register. Enters the fraction symbol (/) in programs and algebraic expressions.

[←][ABS] Calculates the absolute value of vectors or the modulus of a complex number.

[][ARG] Calculates the argument, or angle, formed by the vector representing a complex number and the x (or real) axis.

The ALPHA key

[ALPHA]	Press it once followed by any alphabetic key to enter that letter in upper case.
[ALPHA][ALPHA]	Locks the alphabetic keyboard in upper case (default flag setting). Pressing [↰] before typing any letter when the alphabetic keyboard is locked, will enter that letter in lower case.
[ALPHA][↰]	Press this keystroke combination followed by any alphabetic key to enter that letter in lower case.
[ALPHA][↰][ALPHA][ALPHA]	This keystroke sequence will lock the alphabetic keyboard in lower case for the default flag setting. Pressing [↰] before typing any letter when the alphabetic keyboard is locked in lower case, will enter that letter in upper case.

Numeric keypad

The next four rows of keys include the [ALPHA], [↰], and [↱], in the first column, the numeric pad in columns two through four, and basic arithmetic operations in the last column. A description of the keys follows:

The numeric keypad consists of the keys [7][8][9][4][5][6][1][2][3][0], listed by rows first, then by columns. Their main function is to enter the corresponding digit. The numeric keypad is completed with the keys for the decimal point [.] and the space [SPC]. All of the numeric keypad keys have left-shift and right-shift functions as listed here:

[↰][S.SLV]	Symbolic SoLVer: access menu for symbolic solver operations.
[↱][NUM.SLV]	NUMeric SoLVer: access menu for numeric solver operations ([↱][SOLVE] in HP 48 G).
[↰][EXP&LN]	access menu for algebraic manipulations using exponential functions and natural logarithms.
[↱][TRIG]	access menu for algebraic manipulations using trigonometric functions.
[↰][FINANCE]	access menu for financial calculations.
[↱][TIME]	access menu for time and alarm setting and operations.
[↰][CALC]	access menu for calculus operations.
[↱][ALG]	access menu for algebraic operations.

[↰][MATRICES] access menu for matrix operations (new for the HP 49 G, [MTH][MATR] used in the HP 48 G).

[↱][STAT] access choose list for statistical data analysis.

[↰][CONVERT] access menu for unit conversion tools.

[↱][UNITS] access unit menus.

[↰][ARITH] access menus for arithmetic operations.

[↱][CMPLX] access menu for complex number operations.

[↰][DEF] used to define a function given an expression of the form 'F(X) = …' in register x. For example, to define the function

$$F(X) = X^2,$$

type:

[EQW][ALPHA][F][↰][( )][X][▶] [↱][=] [X][y^x][2] [ENTER] [↰][DEF] [VAR]

A variable F is available in your soft key menu. Enter [↱][F] to see the contents of that variable. The result is a program:

```
<<  → X 'X^2.' >>
```

This is interpreted in the following way:

→ X means "enter the value in stack level 1 as the local variable X in this program',

'X^2.' means "take the value in local variable X and raised to the second power. The result shows up in register x".

Basically, the program evaluates the function F(X) for the current value of the x register, when you press the soft menu key [F]. As an example, try

[2][F]

The result is, of course, 4.

[↱][LIB] access libraries and memory ports.

[↰][#] use it to enter numbers in binary, octal, or hexadecimal bases.

[↱][BASE] access menu for conversions between different numerical bases.

[←][∞] enters the symbol for infinity.

[→][→] enters the slender arrow character. This character is used to indicate entering local variables in a program (see example for F(X) above). It can also be used as a letter in labeling variables.

[←][::] the double colon is used to specify location of objects stored in port memory.

[→][↵] enters the feed line character for text output.

[←][π] enters the constant π.

[→][,] enters a comma.

Arithmetic operation keys

The following three keys correspond to the arithmetic operations of multiplication, subtraction, and addition, as well as to the ON and ENTER keys.

[×] multiplies contents of registers x and y. In programs and algebraic expressions it enters the multiplication symbol *

[←][[ ]] enters a set of square brackets leaving the cursor ready to fill up its interior. Square brackets are used to create vectors and arrays.

[→][" "] enters a set of double quotes leaving the cursor ready to fill up the space in between with characters. Double quotes are used to enter text strings.

[−] subtract contents of register x from those of register y. In programs and algebraic expressions, it enters the subtraction symbol -

[←][()] enters a set of parentheses leaving the cursor ready to fill up its interior. Parentheses are used to group terms in algebraic expressions, and to write complex numbers.

[→][_] enters the an underline character. The underline character is used mainly with unit objects.

[+] adds contents of registers x and y. In programs and algebraic expressions, it enters the addition symbol +

[←][{}] enters a set of curly brackets leaving the cursor ready to fill up its interior. Curly brackets are used to create lists of objects.

[→][" "] enters a set of double quotes leaving the cursor ready to fill up the space in between with characters. Double quotes are used to enter text strings.

[ON] used to turn the calculator on, or to cancel any operation when pressed by itself while the calculator is already on. (Notice the white label CANCEL below the key).

[←][CONT] CONTinue. Use to continue certain type of calculator operations.

[→][OFF] turns the calculator off.

[ENTER] used to enter input into stack level 1 (register x).

[←][ANS] ANSWER. Recalls the last answer obtained.

[→][→NUM] obtains the numerical value of the expression in register x.

Basic calculator operation

The previous two sections were aimed at getting you acquainted with your calculator keyboard, as well as introducing some basic concepts related to its operation. In this section we present several basic calculator functions useful in numerical computations.

Undo, Arg, and Cmd

- If you make a mistake in your calculations you may be able to recover your stack by pressing [↱][UNDO] ([HIST] key).
- If you want to re-use the arguments in the latest calculation, try [↱][ARG] ([÷] key).
- To re-use a previous command you can use the keystroke sequence [↰][CMD]. This will show a list of the last four commands used in the calculator. Highlight the command you want to re-use, and press [OK].

Deleting variables

Sometimes you will need to delete variables in the directories and subdirectories to free up memory space. Here are some hints on how to perform such operations:

- Press [VAR] to show all variables in the current directory. The variables will be shown at the bottom of the display, corresponding to the white buttons in the top row of the calculator. If there are more than six variables in any given directory, use the [NXT] or [↰][PREV] keys to view all of them.

- To delete a single variable or subdirectory in the current directory: place the name of the variable in display's level 1 by pressing [ALPHA][ALPHA] and typing the variable name, followed by [ENTER], or, simply, by entering [↱] ['] and pressing the soft menu key corresponding to the variable of interest. Then, press [TOOL][PURG]. Press [VAR] to recover the variables menu. The variable name corresponding to the variable that you just purged will no longer be available.

- To delete several variables at once, create a list of the variables to be purged, by using [↰][{}]; then, press the soft menu keys corresponding to each of the variables to be purged. When the list is complete, press [ENTER]. To purge the list, press [TOOL][PURG]. The names of the purged variables will disappear from the labels of the soft menu keys.

Transferring data between two HP 49 G calculators

Suppose you want to use the HP 49 G cable to transfer a variable called MYDAT to another calculator. The procedure for transferring directories or variables is as follows:

- Receiver calculator:

    1. Press [APPS][▼][OK] to select the Input/Output (I/O) functions.
    2. Press [▼][OK] to select the option `Get from HP 49` from the choose box.

- Sender calculator:

1. Press [APPS][▼][OK] to select the Input/Output (I/O) functions.
2. Press [OK] to select the option `Send to HP 49` from the choose box.

3. Press [CHOOS] and select the name of the object to be transferred (MYDAT, in this case).
4. Press [SEND]

Note: in step 3 for the sender calculator you can choose a list of variables by pressing [↰][{}] while the *Name:* field is selected. Then, press [VAR], and press the soft menu keys corresponding to all the variables you want to transfer at once. Each variable name will be placed in the list, separated by spaces. Press [ENTER] when done selecting variables. To send the list of variables, press [SEND].

Transferring data from the HP48 to the HP 49

The HP 49 G can be operated as a receiver calculator according to the instructions presented immediately above. For the HP 48 G/G+/GX calculator on the other end of the wire use the following commands:

- HP 48 G/G+/GX as sender calculator:

1. Press [↱][I/O] to select the Input/Output (I/O) functions.
2. Press [▼] four times to highlight the option Transfer... This will produce a screen called TRANSFER, which will show the current I/O parameters for the HP 48 G/G+/GX calculator. Modify them, if needed, so that the following values are set:

```
PORT: Wire      TYPE: Kermit
NAME:
FMT: ASC        XLAT: Newl  CHK:3
BAUD:9600       PARITY:None _OVRW
```

3. Select the name or list of names to be sent to the HP 49 G calculator. These will show in front of the *NAME:* field in the TRANSFER screen.
4. Press [SEND] when ready to send the variable(s) to the HP 49 G calculator.

Transferring data from the HP49 to the HP 48

- HP 48 G/G+/GX as receiver calculator:

1. Press [↱][I/O] to select the Input/Output (I/O) functions.
2. Press [▲] to highlight the option Start Server. This will produce a blank screen with the message *Awaiting Server Cmd.*

- HP 49 as sender calculator:

1. Press [APPS][▼][OK] to select the Input/Output (I/O) functions.
2. Press [▼] four times to select the option highlight the option Transfer... This will produce a screen called TRANSFER, which will show the current I/O parameters for the HP 49 G calculator. Modify them, if needed, so that the following values are set:

```
PORT: Wire      TYPE: Kermit
NAME:
FMT: ASC        XLAT: Newl  CHK:3
BAUD:9600       PARITY:None _OVRW
```

3. Select the name or list of names to be sent to the HP 49 G calculator. These will show in front of the *NAME:* field in the TRANSFER screen.
4. Press [SEND] when ready to send the variable(s) to the HP 49 G calculator.

Note: not all variables can be transferred between the HP 48 G/G+/GX and the HP 49 G calculators. In such cases you will get a *Syntax Error* message and the transfer will be aborted.

How to type Greek letters and other characters

To type characters now shown in the keyboard, the general procedure is to use [↱][CHARS] to access the table of text characters, as indicated in the keyboard description above. You can use the arrow keys ([◄],[►],[▲], and [▼]) to move to any desired character. If the character is not available in the current screen, you can scroll the character list up or down using the appropriate key until the desired character appears in the display.

Once the desired character is highlighted, press [ECHO1] to copy it to the stack and return to normal calculator display. Press [ENTER] to enter the character, as an algebraic expression, in register x.

To copy more than one character, select the characters, one by one, and press [ECHO] after selecting each of them. When done, press [ENTER]. Press [ENTER] again to enter the string of characters, as an algebraic expression, in register x.

Keyboard shortcuts for special characters

Many of the Greek letters and mathematical characters can be typed directly from the keyboard by preceding the letter keys with the keystroke combination [ALPHA][↱]. The characters corresponding to each of the letters of the alphabet combined with [ALPHA][↱] are as follows:

A:	α	B:	β	C:	Δ	D:	δ	E:	ε	F:	ρ
G:	(none)	H:	(none)	I:	|	J:	(none)	K:	(none)	L:	(none)
M:	μ	N:	λ	O:	'	P:	Π	Q:	^	R:	√
S:	σ	T:	θ	U:	τ	V:	ω	W:	=	X:	<
Y:	>	Z:	/								

Some special characters are also available by combining the keystroke sequence [ALPHA][↱] with the numeric pad, as follows:

1:	~	2:	**!**	3:	**?**	4:	**(see calculator)**	5:	\
6:	∠	7:	**(none)**	8:	**(none)**	9:	**(none)**	0:	→

Changing the display format

Typically, the display format used is the *standard format* (STD), which adjust the number of decimals shown according to whether or not the number displayed is an integer. For example, if you enter the number 2.5 ([2][.][5]) when the standard format is active, the display will show just 2.5. Press now, [↱][LN], and you get .916290731874. The standard format uses up to 12 decimal places for non-integer results.

- Use the following keystroke sequence to access the format change environment:

  [↰][PRG][NXT][MODES][FMT].

- To fix the number of decimals places used, say to three decimal places, use the following keystroke sequence: [3][FIX]. The displayed result will now be 0.916.

- To return to the standard display format you may press [STD]. The current display format will be marked by a dot in the corresponding white key at the top of the keyboard.

Note that in the format change environment there are also soft menu keys labeled [SCI][ENG][FM,][ML]. The [SCI] and [ENG] keys refer to what calculator manufacturers call *Scientific* and *Engineering* notations, respectively, which provides results using powers of ten.

The [FM,] button, when marked by a dot, changes the decimal point to a coma. Press [FM,] and the displayed number will read 0,916. Press [FM,] again to select the decimal point.

Press [VAR] to return to your variable menu.

Note: An alternative way to change the format is to press the [MODE] key, then press [▼] to access the Number Format... field. Use the CHOOSE box to change the number format, or toggle the [+/-] button until the proper selection is displayed in the number format field. If setting the number format to fix, make sure to indicate the number of significant figures in your result in the appropriate field.

Exercises using different number formats

Try the following exercises:

Using the standard format, enter the number 2.5689, press [ENTER] four times:

[2][.][5][6][8][9] [ENTER][ENTER][ENTER][ENTER]

Calculate:

[×]	Result: 6.59924721
[×]	Result: 16.9528061578
[×]	Result: 43.5500637388
[↰][x^2]	Result: 1896.60805165
[↰][x^2]	Result: 3597122.10158
[↰][x^2]	Result: 1.29392874137E13 (power of ten notation, $1.2939\ldots\times10^{13}$)

Notice that all the results show 12 significant figures when using the standard number format.

Change the mode to FIX with 3 decimals:

[MODE][▼][CHOOS][▼][OK][►][3][OK]

and repeat the same calculations as before:

[2][.][5][6][8][9] [ENTER][ENTER][ENTER][ENTER]

Calculate:

[×]	Result: 6.599
[×]	Result: 16.952
[×]	Result: 43.550
[↰][x^2]	Result: 1896.608

[↰][x^2] Result: 3597122.101
[↰][x^2] Result: 1.293E13

Change the mode to SCIENTIFIC with 5 significant figures:

[MODE][▼][CHOOS][▼] [▼] [OK][►][5][OK]

and repeat the same calculations as before:

[2][.][5][6][8][9] [ENTER][ENTER][ENTER][ENTER]

Calculate:

[×] Result: 6.59925E0
[×] Result: 1.69528E1
[×] Result: 4.35501E1
[↰][x^2] Result: 1.89661E3
[↰][x^2] Result: 3.59712E6
[↰][x^2] Result: 1.29393E13

Note: the main characteristic of the *scientific* number format is that there is always one integer digit.

Change the mode to ENGINEERING with 5 significant figures:

[MODE][▼][CHOOS][▼][OK] [OK][►][5][OK]

and repeat the same calculations as before:

[2][.][5][6][8][9] [ENTER][ENTER][ENTER][ENTER]

Calculate:
[×] Result: 6.59925E0
[×] Result: 16.9528E0
[×] Result: 43.5501E0
[↰][x^2] Result: 1.89661E3
[↰][x^2] Result: 3.59712E6
[↰][x^2] Result: 12.9393E12

Note: the main characteristic of the *engineering* number format is that the power of ten is a multiple of 3.

Entering numbers as powers of ten

Typically, powers of ten are used to write numbers whose absolute values are relatively large (e.g., 1.2×10^{13}) or very small (e.g. 2.3×10^{-16}). The HP 49 G, as most calculators and computer software, uses the notation $E\pm n$, where n stands for an integer number ($n \le 499$), to indicate a power of ten. The character sequence $E\pm n$ is used to replace the $\times 10^{\pm nn}$ component of a number, if needed, when entering the number into the calculator display.

For example, the number 1.2×10^{13} is entered by using [1][.][2][EEX][1][3][ENTER]. This number is displayed as 1.2E13 if using the standard calculator display. A number with a negative power of ten, e.g., 2.3×10^{-16}, is entered as [2][.][3][EEX][1][6][+/-][ENTER]. This number will be displayed as 2.3E-16.

Changing the angle mode and coordinate system

Using the [MODE] key also provides access to the Angle Measure... option, whose setting can be changed to Degrees, Radians, or Grads (π radians = 180 degrees = 200 grads). As with the number format, angle units can be changed by pressing [CHOOS] and selecting the appropriate units, or by toggling the [+/-] sign until the desired units appear in the proper field.

You can access the angle/coordinate change environment directly from the keyboard by pressing:

[↰][PRG][NXT][MODES][ANGLE].

In this environment, you will see the following soft menu key labels:

[DEG][RAD][GRAD][RECT][CYLIN][SPHER],

referring to the angle mode as in (sexagesimal) DEGrees, RADians, or (decimal) GRADes; and to the RECTangular, CYLINdrical (polar), and SPHERical coordinate systems. For most applications we use the rectangular coordinate system, and the angles in degrees or radians.

As an example, press the keys labeled [RECT] and [DEG] to set rectangular coordinates and angle in degrees. Then, enter a vector of three components, say [2 3 5]. Use the following keystroke sequence:

[↰][[ ]][2][SPC][3][SPC][5][SPC][ENTER]

The calculator assumes that the three components of the vector correspond to the x,y,z, components of Cartesian or rectangular coordinates. The current selection of angle and coordinates is shown in the top line of the display as DEG XYZ.

If you now press [CYLIN], the three-dimensional vector gets transformed to

[3.606 ∠56.310 5.00],

where the symbol ∠ indicates an angle. (The character can be typed in by using the sequence [ALPHA][↱][6]). Notice that the characters R∠Z appear instead of XYZ in the upper left corner of the display. This change indicates that the components of the vector are now the polar cylindrical coordinates r = 3.606, $\theta = 56.310^{o}$, and, z = 5.00.

Pressing the key [SPHER] will produce the following vector:

[6.165 ∠56.310 ∠35.796],

which correspond to the spherical coordinates, $\rho = 6.165$, $\theta = 56.310^{o}$, $\phi = 35.796^{o}$. The upper left corner of the display will show the characters: R∠∠ instead of R∠Z.

We could change our angle units to radians by pressing [RAD]. Notice that the vector in the display now reads:

[6.164 ∠0.983 ∠0.625],

and the upper left corner of the display shows the characters RAD in front of the cylindrical coordinate descriptor R∠∠. If you press the key [GRAD], the vector will be displayed as

[6.164 ∠62.567 ∠39.773],

while the upper left corner of the display shows the characters GRAD in front of the cylindrical coordinates descriptor R∠∠. The decimal GRADes are not commonly used in practice.

Try the following exercise:

[MTH][VECTR][NXT][RECT] [↰][[ ]][2][SPC][3][SPC][ENTER] [CYLIN]

If the RAD indicator is shown, you will get

[3.606 ∠0.983].

Press [DEG], to get

[3.606 ∠56.310].

Important relationships between angle units

As a reminder, recall that the basic transformation between angle units is as follows:

$\theta^r/\theta^o = \pi/180,$

$\theta^r/\theta^d = \pi/200,$

$\theta^o/\theta^d = 90/100 = 9/10.$

Quick conversions from degrees to radians and vice versa

Quick conversions from degrees to radians, and vice versa, can be accomplished by using the sequence:

[↰] [MTH][REAL][NXT][NXT][D→R], and [R→D], respectively.

For example, try:

[3][7] [↰] [MTH][REAL][NXT][NXT][D→R] to convert 37^o to 0.646 rad.

Also, try

[3][.][1][4] [↰] [MTH][REAL][NXT][NXT][R→D] to convert 3.14 rad to 179.909^o.

Important relationships between coordinate systems

Coordinate transformations are given by the following expressions:

- Rectangular & cylindrical coordinates:

$r = (x^2 + y^2)^{1/2}$, $\tan\theta = y/x$,

$x = r\cos\theta$, $y = r\sin\theta$

- Rectangular & spherical coordinates:

$\rho = (x^2 + y^2 + z^2)^{1/2}$, $\tan\theta = y/x$, $\tan\phi = z/(x^2 + y^2)^{1/2}$,

$x = \rho \sin\phi \cos\theta$, $y = \rho \sin\phi \sin\theta$, $z = \rho \cos\phi$.

Make sure that you reset your coordinate system to rectangular before continuing with this tutorial.

Additional examples on angle measure and coordinate system conversions

Assuming that the coordinate system is set to Cartesian, the angle measure to degrees, and the number format to standard. Enter a vector [1 2 5], i.e., the Cartesian components of the vector are

$x = 1, y = 2, z = 5$:

[↰][[ ]] [1][SPC][2][SPC][5][ENTER] Result: [1. 2. 5.]

Change to cylindrical coordinates:

[↰][MTH][VECTR][NXT][CYLIN] Result: [2.236 ∠63.43….]

Change number format:

[MODE][▼][CHOOS][▼][OK][▶][2][OK] Result: [2.236 ∠63.43 5.00]

In cylindrical coordinates, therefore, the components of the vector are $r = 2.24$, $\theta = 64.43^o$, and $z = 5.00$. Now, let's change coordinates to spherical:

[SPHER] Result: [5.48 ∠63.43 ∠24.09].

The components of this vector in spherical coordinates are $\rho = 5.48$, $\theta = 64.43^o$, and $\phi = 24.09^o$.

Keeping the vector currently in register x, enter the following vector in spherical coordinates:

[3.2 ∠27.5 ∠16]:

[↰][[ ]] [3][.][2][SPC] [ALPHA][↱][6] [2][7][.][5][SPC] [ALPHA][↱][6] [1][6][ENTER]

Resulting in: [3.20 ∠27.50 ∠16.00]:

Add the two vectors:

[+] Result: [8.61 ∠53.48 ∠20.35].

Convert to different coordinate systems:

[RECT] Result: [1.78 2.41 8.08].

[CYLIN] Result: [3.00 ∠53.48 8.08]:

HP 49 G standard mathematical constants

The following are the mathematical constants used by your calculator:

- *e*: the base of natural logarithms.
- *i*: the imaginary unit, $i^2 = -1$.
- π: the ratio of the length of the circle to its diameter.
- MINR: the minimum real number available to the calculator.
- MAXR: the maximum real number available to the calculator.

To have access to these constants, use the combination:

[↰][MTH][NXT][CONST].

The calculator display will show buttons corresponding to the following variables:

[E][2.718][I][(0.00][π][3.142].

Press [NXT] to get

[MINR][1.000][MAXR][1.000].

Press [2.718] to get the value of *e*, 2.718 in the display. If you press [E], you will get the variable name in the display, namely, `'e'`. To get the numerical value, press [↰][→NUM].

Similar results are obtained by using the other built-in constants or their values from the soft menu keys.

Physical constants available in the HP49 G calculator

There is a library of physical constants built in into the calculator. This library of physical constants is associated with the HP 48 G menu for the equation library (EQ LIB). The equation library is a set of equation sets commonly used in physics and engineering that is built in into the HP 48 G. The developers of the HP 49 G decided not to include the equation library in the new calculator. However, the other menus associated with the equation library are still available in the HP 49 G calculator, although the way to access them is partially hidden.

Utility menus adapted from the HP 48 G

After many years of experience with the HP 48 G I have grown attached to certain utility menus that I have found to be very useful in calculator operations. I have created a directory, called UTL48 (for UTiLities 48), that contains the following menus:

[STATm]	to access the soft menu for statistical applications.
[PLOtm]	to access the soft menu for plotting.
[SYMBm]	to access the old soft menu for symbolic operations.
[EQLIBm]	to access the equation library menu. Although there is not an equation library in the HP 49 G, as there is in the HP 48 G, the utilities listed under this menu are available in the HP 49 G for ROM version 1.16 on.
[LIBm]	to access the old soft menu for library operations.
[SOLVEm]	to access the old SOLVER menu. This is actually a left over from the HP 48 S series, but I still find it very useful for some applications.

You can create this directory in your calculator too within the HOME directory by following these instructions:

[ALPHA][ALPHA][U][T][L][4][8][ENTER]	Enter the name 'UTL48' in register x
[↰][PRG][MEM][DIR][CRDIR]	Create directory UTL48
[VAR][UTL48]	Enter directory UTL48

The keystrokes shown below will create the programs corresponding to the different menus listed above:

[↱][<< >>] [7][4][.][0][1] [SPC] [ALPHA][ALPHA] [M][E][N][U] [ENTER]
[ALPHA][ALPHA] [S][O][L][V][E][↰][M] [STO▶]

[↱][<< >>] [1][1][0][.][0][1] [SPC] [ALPHA][ALPHA] [M][E][N][U] [ENTER]
[ALPHA][ALPHA] [L][I][B][↰][M] [STO▶]

[↱][<< >>] [1][1][3][.][0][1] [SPC] [ALPHA][ALPHA] [M][E][N][U] [ENTER]
[ALPHA][ALPHA] [E][Q][L][I][B][↰][M] [STO▶]

[↱][<< >>] [9][3][.][0][1] [SPC] [ALPHA][ALPHA] [M][E][N][U] [ENTER]
[ALPHA][ALPHA] [S][Y][M][B][↰][M] [STO▶]

[↱][<< >>] [8][1][.][0][2] [SPC] [ALPHA][ALPHA] [M][E][N][U] [ENTER]
[ALPHA][ALPHA] [P][L][O][T][↰][M] [STO▶]

[↱][<< >>] [9][6][.][0][1] [SPC] [ALPHA][ALPHA] [M][E][N][U] [ENTER]
[ALPHA][ALPHA] [S][T][A][T][↰][M] [STO▶]

Using the *LibMakr* library, you can create a library out of this directory, that you can then load onto your port memory, and have these soft key menus readily accessible in any of your directories.

Accessing the EQ LIB menus

One way to access the EQ LIB menus is to use the program [EQLIBm] proposed above. If you have that one ready, go ahead and press [EQLIBm]. If you don't have it ready, or do not want to move to that directory at this point, simply enter the following in your stack to activate that menu:

[1][1][3][.][0][1] [ENTER]
[ALPHA][ALPHA] [M][E][N][U] [ENTER]

As a result, you get the following soft menu keys:

[EQLIB][COLIB][MES][UTILS]

The [EQLIB] key has no definition in the HP 49 G, as mentioned before. [MES] provides access to the Multiple Equation Solver (MES), which will be discussed later. [UTILS] provides some utility functions used in selected engineering disciplines such as fluid mechanics. At this point, however, we are interested only in using the [COLIB] (COnstants LIBrary) command.

Accessing the constants library

Press [COLIB] to access the soft menu keys:

[CONLI][CONST][ ][ ][ ][EQLIB]

Pressing [CONLI] will generate a table of physical constants. The window is labeled CONSTANTS LIBRARY, and it lists the symbol and meaning of several physical constants starting with Avogadro's number. By using the up and down arrow keys you can navigate through the list of constants.

The soft menu keys available for this option include:

[SI][ENGL][UNIT][VALUE][→STK][QUIT]

By pressing [SI] or [ENGL] you select the system of units for the constants, SI = Systeme International (the International system of units), and ENGL = English, British, or Imperial system of units (ES).

Press the [VALUE] key to see the values of the constants listed in the list. If the [UNIT] key is activated (a dark square is shown), the units in the selected system are shown. Toggle the [UNIT] key to deselect unit display. The values of the constants are shown without units. Press [UNIT] once more to recover the units display.

If you want to copy the value of a particular constant to the stack, select the constant and press [→STK]. Press [QUIT] to leave the Constant Library environment.

The function CONST

The soft menu that is now available includes a function, [CONST], and a the [EQ LIB] folder. The CONST function is used to recover the value of a constant if the name of the constant is shown as an algebraic expression in register x. The value reported will correspond to the system of units selected last within the library constant environment. Try the following exercise: g is the name of the constant corresponding to the acceleration of gravity. Type:.

[ALPHA][↰][G][ENTER] [CONST]

The value of g will be shown in the display in the selected system of units.

Accessing the constant library through the command catalog

The constant library can be accessed directly from the keyboard by using the [CAT] key. The command to access the library is [CONLI] (actually, the full name is CONLIB), therefore, you should search for that command in the catalog. Use the following keystrokes:

[CAT]
[ALPHA][ALPHA][C][O][ALPHA],

then, use the down arrow key to scroll down the command catalog until the CONLIB command is highlighted. When ready, press [OK]. The list of physical constants will be available for you .

Using the command catalog

The command catalog is accessible by pressing the [CAT] key. It produces an ordered list of all of the calculator's ROM commands as well as library functions loaded by the user. Library function names are shown in *italics*. The catalog lists commands starting with a few names that use non-alphabetical characters (i.e., !, %, %CH, etc.), then listing in alphabetical order those commands whose names start with upper-case letters of the English alphabet. After exhausting the letters of the alphabet, the catalog lists commands that start with other non-alphabetical characters, lower-case letters of the English alphabet, and some that start with Greek letters and arrows.

To see the start of the catalog use [↱][▲]. Then use the down arrow key, [▼], to see the few commands that start with non-alphabetical characters before the command ABCUV (which starts the alphabetical listing of command names) shows up in the catalog. To see the end of the catalog use [↱][▼]. The very last command is the symbol >> (which signals the end of a program). Use the upper arrow key, [▲], to see the commands at the bottom of the catalog. There are quite a few commands that start with non-alphabetic characters before reaching the last command whose name uses an upper-case letter (ZVOL).

To access a particular command, press [ALPHA] followed by the first letter of the command. Then, use the up and down arrow keys to highlight the desired command. Press [OK] to activate the command. You can also enter more than the first letter in a command name by using [ALPHA][ALPHA] followed by two or more of the first letters of the command. Press [ALPHA] when you're done, before pressing [OK] to activate the command.

Working with units in the HP 49 G calculator

Working with units entails searching through a number of menus in the calculator where the units are defined. Due to the lengthy process involved in assigning units when using the HP4G or GX calculator, my personal preference is to work without units as much as I can. When you do that, however, make sure you are using a consistent system of units (i.e., all standard base unit in the SI, or all in the English system).

To illustrate the use of units, let's calculate a force, F, given the mass,

$$m = 3.5 \text{ kg},$$

and the acceleration,

$$a = 2.3 \text{ cm/s}^2.$$

From Newton's second law,

$$F = m\,a,$$

we have,

$$F = (3.5\ kg)(\ 2.3\ cm/s^2).$$

To perform this calculation use the following:

[3][.][5]	Enter the numeric value of m
[↱][UNITS][NXT][MASS][KG]	Select kg units in the "mass" menu.
[2][.][3] [↱][UNITS][SPEED][CM/S]	Select units of velocity since units of acceleration are not available.
[1][↱][UNITS][TIME][S]	Select units of time (s), to calculate a = v/t.
[÷]	Gives units of acceleration (cm/s^2)
[×]	To calculate F = m·a (`8.050_Kg*cm/s^2`)
[ENTER][ENTER]	Make two more copies of the result for future use.

Next, we demonstrate some operations that can be performed using the UNITS menu:

[↱][UNITS][TOOLS][UBASE]	Converts to basic units of the SI system.
[⇦]	Drop contents of level 1.
[UVAL]	Eliminates units, retains numeric value.
[⇦]	Drop contents of level 1.
[1][↱][UNITS][NXT][FORCE][LBF]	Enters 1 lbf in level 1. We'll convert the value in level 2, which is in Kg cm/s2, into lbf (pound force), a unit in the English System.
[↱][UNITS][TOOLS][UBASE][CONVE]	Converts value in level 2 to units in level 1.

The latest operation, i.e., *unit conversions*, is about the most useful I can think of in the UNITS menu.

This operation can also be accessed by pressing [↰][CONVERT] (the key for [6]), followed by soft menu keys [UNITS][TOOL][CONVE].
A complete list of units is presented in pages 12 and 13 of the HP 49 POCKET GUIDE.

A household practical problem using units

Here is a practical problem from a household kitchen:

- How many pints in a gallon?

[↱][UNITS][VOL][1][NXT][GAL][1][PT]
[↰][CONVERT][UNITS][TOOLS][CONV] (Result: 1 gallon = 8 pints);

- How many cups in a pint?:

[↱][UNITS][VOL] [1][NXT][PT] [1][NXT][CU]
[↰][CONVERT][UNITS][TOOLS][CONV] (Result: 1 pint = 2 cups).

Universal gas law

The ideal gas law is written as

$$pV = nRT,$$

where:

- p = gas pressure,
- V = gas volume,
- n = number of moles (gmol),
- R = universal gas constant, and
- T = absolute temperature.

We indicated earlier in this chapter that the value of R is readily available from your calculator by using the function CONST(R). To see what is the value of R use:

[↱][‘][ALPHA][ALPHA][C][O][N][S][T][↰] [( )] [R][ALPHA][↱][EVAL]

The value provided is 8.31451_J/(gmol*K). Suppose that for n = 0.5 mol (or gmol), we let T = 280_K, and V = 0.1_m^3, let’s calculate the value of p provided with these values of T and V, use:

[.][5][↱][UNITS][NXT][MASS][NXT][NXT][mol]	Enter 0.5_mol
[▼][▶][▶][▶][▶][ALPHA][↰][G][ENTER]	Modify it to read 40_gmol
[2][8][0][↱][_][ALPHA][K][ENTER]	Enter value of T
[×][×]	Calculate nRT
[.][0][1]][↱][UNITS][VOL][m^3] [÷]	Enter V, and calculate nRT/V

The result is 116403.14_J/m^3. This result does not look like units of pressure. Let’s do some conversion of units as follows:

[ENTER]	Copy the value in the stack
[↰][CONVERT][UNITS][TOOLS][UBASE]	Converts to basic S.I. units, 116403.14_kg/(m*s^2)

This result still does not look like units of pressure. So, let’s try converting to *Pascals*, the preferred unit of pressure in the S.I. system, by using:

[1][↱][UNITS][NXT][PRESS][Pa]	Enter 1_Pa
[][CONVERT][UNITS][TOOLS][CONVE]	Converts quantity in level 2 to units in level 1

The result is 116403.14_Pa, or 116.40kPa.

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