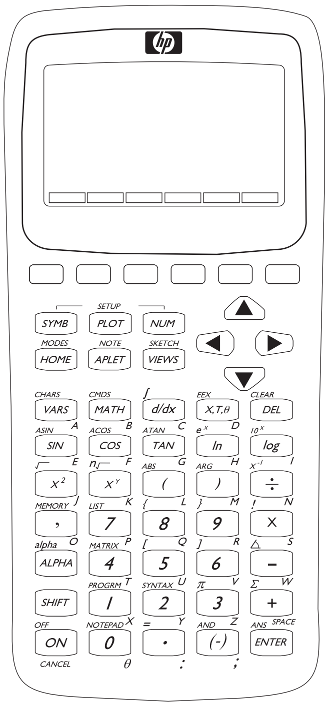
HP 39G/40G

GRAPHING CALCULATOR

USER'S GUIDE

Version 1.1



HEWLETT PACKARD

Contents

Preface

1 Getting started

2 Aplets and their views

9 Inference aplet

10 Using mathematical functions

11 Variables and memory management

12 Matrices

13 Lists

14 Notes and sketches

15 Programming

16 Extending aplets

Reference information

Index

Preface

The HP 39G/40G is a feature-rich graphing calculator. It is also a powerful mathematics learning tool. The HP 39G/40G is designed so that you can use it to explore mathematical functions and their properties.

You can get more information on the HP 39G/40G from Hewlett-Packard's Calculators web site. You can download customized aplets from the web site and load them onto your calculator. Customized aplets are special applications developed to perform certain functions, and to demonstrate mathematical concepts.

Hewlett Packard's Calculators web site can be found at:

www.hp.com/calculators

Manual conventions

The following conventions are used in this manual to represent the keys that you press and the menu options that you choose to perform the described operations.

- Key presses are represented as follows:

  SIN, COS, HOME, etc.

- Shift keys, that is the key functions that you access by pressing the SHIFT key first, are represented as follows:

  SHIFT *CLEAR*, SHIFT *MODES*, SHIFT *ACOS*, etc.

- Numbers and letters are represented normally, as follows:

  5, 7, A, B, etc.

- Menu options, that is, the functions that you select using the menu keys at the top of the keypad are represented as follows:

  STOP, CANCL, OK.

- Input form fields and choose list items are represented as follows:

  `Function`, `Polar`, `Parametric`

- Your entries as they appear on the command line or within input forms are represented as follows:

  `2*X`^{2}`-3X+5`

Notice

This manual and any examples contained herein are provided as-is and are subject to change without notice. Except to the extent prohibited by law, Hewlett-Packard Company makes no express or implied warranty of any kind with regard to this manual and specifically disclaims the implied warranties and conditions of merchantaiblity and fitness for a particular purpose and Hewlett-Packard Company shall not be liable for any errors or for incidental or consequential damage in connection with the furnishing, performance or use of this manual and the examples herein.

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1

Getting started

On/off, cancel operations

To turn on

Press [ON] to turn on the calculator.

To cancel

When the calculator is on, the [ON] key cancels the current operation.

To turn off

Press [SHIFT] *OFF* to turn the calculator off.

To save power, the calculator turns itself off after several minutes of inactivity. All stored and displayed information is saved.

If you see the ((•)) annunciator or the `Low Bat` message, then the calculator needs fresh batteries.

HOME

HOME is the calculator's home view and is common to all aplets. If you want to perform calculations, or you want to quit the current activity (such as an aplet, a program, or an editor), press [HOME]. All mathematical functions are available in the HOME. The name of the current aplet is displayed in the title of the home view.

The display

To adjust the contrast

Simultaneously press ON and + (or -) to increase (or decrease) the contrast.

To clear the display

- Press *CANCEL* to clear the edit line.
- Press SHIFT *CLEAR* to clear the edit line and the display history.

Parts of the display

Menu key or **soft key labels.** The labels for the menu keys' current meanings. STO▶ is the label for the first menu key in this picture. "Press STO▶" means to press the first menu key, that is, the leftmost top-row key on the calculator keyboard.

Edit line. The line of current entry.

History. The HOME display (HOME) shows up to four lines of history: the most recent input and output. Older lines scroll off the top of the display but are retained in memory.

Title. The name of the current aplet is displayed at the top of the HOME view. RAD, GRD, DEG specify whether Radians, Grads or Degrees angle mode is set for HOME. The ▼ and ▲ symbols indicate whether there is more history in the HOME display. Press the ▼ and ▲ to scroll in the HOME display.

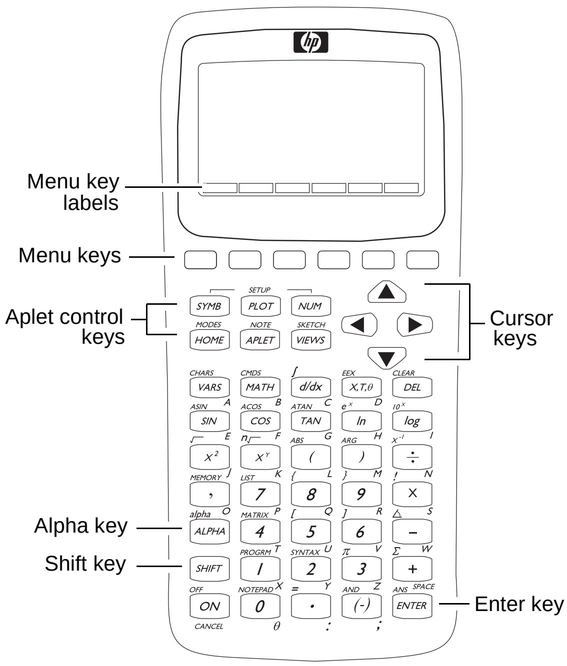
NOTE The HP 40G is packaged with a computerized algebra system (CAS). Press CAS to access the computerized algebra system. This User's Guide contains images from the HP39G and do not display the CAS menu key label.

Annunciators. Annunciators are symbols that appear above the title bar and give you important status information.

Annunciator	Description
	Shift in effect for next keystroke. To cancel, press SHIFT again.
α	Alpha in effect for next keystroke. To cancel, press ALPHA again.
((•))	Low battery power.
⧗	Busy.
⋙	Data is being transferred via infrared or cable.

The keyboard

Menu keys



- On the calculator keyboard, the top row of keys are called menu keys. Their meanings depend on the context—that's why their tops are blank. The menu keys are sometimes called "soft keys".
- The bottom line of the display shows the labels for the menu keys' current meanings.

Aplet control keys

The aplet control keys are:

Key	**Meaning**
SYMB	Displays the Symbolic view for the current aplet. See "Symbolic view" on page 1-15.
PLOT	Displays the Plot view for the current aplet. See "Plot view" on page 1-15.
NUM	Displays the Numeric view for the current aplet. See "Numeric view" on page 1-15.
HOME	Displays the HOME view. See "HOME" on page 1-1.
APLET	Displays the Aplet Library menu. See "Aplet library" on page 1-15.
VIEWS	Displays the VIEWS menu. See "Aplet views" on page 1-15.

Entry/Edit keys

The entry and edit keys are:

Key	Meaning
ON (*CANCEL*)	Cancels the current operation if the calculator is on by pressing ON. Pressing SHIFT, then *OFF* turns the calculator off.
SHIFT	Accesses the function printed in blue above a key.
HOME	Returns to the HOME view, for performing calculations.
ALPHA	Accesses the alphabetical characters printed in orange below a key. Hold down to enter a string of characters.
ENTER	Enters an input or executes an operation. In calculations, ENTER acts like "=". When OK or START is present as a menu key, ENTER acts the same as pressing OK or START.
(-)	Enters a negative number. To enter –25, press (-)25. *Note: this is not the same operation that the subtract button performs* (-).
X,T,θ	Enters the independent variable by inserting *X*, *T*, θ, or *N* into the edit line, depending on the current active aplet.
DEL	Deletes the character under the cursor. Acts as a backspace key if the cursor is at the end of the line.
SHIFT *CLEAR*	Clears all data on the screen. On a settings screen, for example Plot Setup, SHIFT *CLEAR* returns all settings to their default values.
◄, ►, ▲, ▼	Moves the cursor around the display. Press SHIFT first to move to the beginning, end, top or bottom.
SHIFT *CHARS*	Displays a menu of all available characters. To type one, use the arrow keys to highlight it, and press OK. To select multiple characters, select each and press ECHO, then press OK.

Shifted keystrokes

There are two shift keys that you use to access the operations and characters printed above the keys: SHIFT and ALPHA.

Key	Description
SHIFT	Press the SHIFT key to access the operations printed in blue above the keys. For instance, to access the Modes screen, press SHIFT, then press HOME. (*MODES* is labelled in blue above the HOME key). You do not need to hold down SHIFT when you press HOME. This action is depicted in this manual as "press SHIFT *MODES*." To cancel a shift, press SHIFT again.
ALPHA	The alphabetic keys are also shifted keystrokes. For instance, to type Z, press ALPHA Z. (The letters are printed in orange to the lower right of each key.) To cancel Alpha, press ALPHA again. For a lower case letter, press SHIFT ALPHA. For a string of letters, hold down ALPHA while typing.

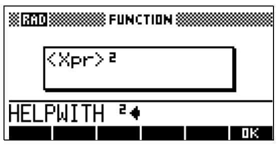
HELPWITH

The HP 39G built-in help is available in HOME only. It provides syntax help for built-in math functions.

Access the HELPWITH command by pressing SHIFT *SYNTAX* and then the math key for which you require syntax help.

Example

Press SHIFT *SYNTAX* x^2 ENTER



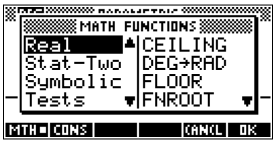
Note: Remove the left parenthesis from built-in commands such as sine, cosine, and tangent before invoking the HELPWITH command.

Math keys

HOME (HOME) is the place to do calculations.

Keyboard keys. The most common operations are available from the keyboard, such as the arithmetic (like +) and trigonometric (like SIN) functions. Press ENTER to complete the operation: SHIFT √ 256 ENTER displays 16.

MATH menu. Press MATH to open the MATH menu. The MATH menu is a comprehensive list of math functions that do not appear on the keyboard. It also includes categories for all other functions and constants. The functions are grouped by category, ranging in alphabetical order from Calculus to Trigonometry.



- The arrow keys scroll through the list (▼, ▲) and move from the category list in the left column to the item list in the right column (◄, ►).
- Press **OK** to insert the selected command onto the edit line.
- Press **CANCL** to dismiss the MATH menu without selecting a command.
- Pressing **CONS** displays the list of Program Constants. You can use these in programs that you develop.
- Pressing **MTH** takes you to the beginning of the MATH menu.

See "Math functions by category" on page 10-3 for details of the math functions.

HINT When using the MATH menu, or any menu on the HP 39G/40G, pressing an alpha key takes you straight to the first menu option beginning with that alpha character. With this method, you do not need to press ALPHA first. Just press the key that corresponds to the command's beginning alpha character.

Program commands

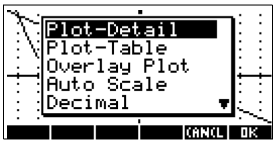
Pressing SHIFT *CMDS* displays the list of Program Commands. See "Programming commands" on page 15-14.

Inactive keys

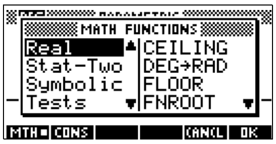
If you press a key that does not operate in the current context, a warning symbol like this ⚠ appears. There is no beep.

Menus

A menu offers you a choice of items. Menus are displayed in one or two columns.



- The ▼ arrow in the display means more items below.
- The ▲ arrow in the display means more items above.



To search a menu

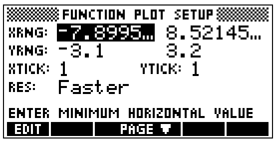
- Press [▼] or [▲] to scroll through the list. If you press [SHIFT] [▼] or [SHIFT] [▲], you'll go all the way to the end or the beginning of the list. Highlight the item you want to select, then press **OK** (or [ENTER]).
- If there are two columns, the left column shows general categories and the right column shows specific contents within a category. Highlight a general category in the left column, then highlight an item in the right column. The list in the right column changes when a different category is highlighted. Press **OK** or [ENTER] when you have highlighted your selection.
- To speed-search a list (with no edit line), type the first letter of the word. For example, to find the Matrix category in [MATH], press [)], the Alpha "M" key.
- To go up a page, you can press [SHIFT] [◄]. To go down a page, press [SHIFT] [►].

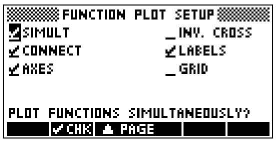
To cancel a menu

Press [ON] (for *CANCEL)* or **CANCL**. This cancels the current operation.

Input forms

An input form shows several fields of information for you to examine and specify. After highlighting the field to edit, you can enter or edit a number (or expression). You can also select options from a list (CHOOS). Some input forms include items to check (✓CHK). See below for an example of an input form.





Reset input form values

To reset a default field value in an input form, move the cursor to that field and press DEL. To reset all default field values in the input form, press SHIFT *CLEAR*.

Mode settings

You use the Modes input form to set the modes for HOME.

HINT Although the numeric setting in Modes affects only HOME, the angle setting controls HOME and the current aplet. The angle setting selected in Modes is the angle setting used in both HOME and current aplet. To further configure an aplet, you use the *SETUP* keys (SHIFT PLOT and SHIFT NUM).

Press SHIFT *MODES* to access the HOME MODES input form.

Setting	Options
Angle Measure	Angle values are: **Degrees**. 360 degrees in a circle. **Radians**. 2π radians in a circle. **Grads**. 400 grads in a circle. The angle mode you set is the angle setting used in both HOME and the current aplet. This is done to ensure that trigonometric calculations done in the current aplet and HOME give the same result.

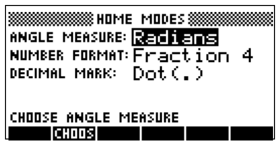
Setting	Options (Continued)
Number Format	The number format mode you set is the number format used in both HOME and the current aplet. **Standard**. Full-precision display. **Fixed**. Displays results rounded to a number of decimal places. Example: 123.456789 becomes 123.46 in Fixed 2 format. **Scientific**. Displays results with an exponent, one digit to the left of the decimal point, and the specified number of decimal places. Example: 123.456789 becomes 1.23E2 in Scientific 2 format. **Engineering**. Displays result with an exponent that is a multiple of 3, and the specified number of significant digits beyond the first one. Example: 123.456E7 becomes 1.23E9 in Engineering 2 format. **Fraction**. Displays results as fractions based on the specified number of decimal places. Examples: 123.456789 becomes 123 in Fraction 2 format, and .333 becomes 1/3 and 0.142857 becomes 1/7. See "Using fractions" on page 1-24.
Decimal Mark	**Dot** or **Comma**. Displays a number as 12456.98 (Dot mode) or as 12456,98 (Comma mode). Dot mode uses commas to separate elements in lists and matrices, and to separate function arguments. Comma mode uses periods (dot) as separators in these contexts.

Setting a mode

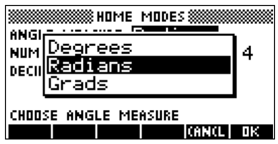
This example demonstrates how to change the angle measure from the default mode, radians, to degrees for the current aplet. The procedure is the same for changing number format and decimal mark modes.

1. Press [SHIFT] *MODES* to open the HOME MODES input form.

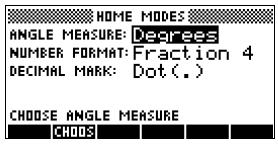
   The cursor (highlight) is in the first field, `Angle Measure`.



2. Press **CHOOS** to display a list of choices.



3. Press [▲] to select `Degrees`, and press **OK**. The angle measure changes to degrees.



4. Press [HOME] to return to HOME.

HINT Whenever an input form has a list of choices for a field, you can press [+] to cycle through them instead of using **CHOOS**.

Aplets (E–lessons)

Aplets are the application environments where you explore different classes of mathematical operations. You select the aplet that you want to work with.

Aplets come from a variety of sources:

- Built-in the HP 39G/40G (initial purchase).
- Aplets created by saving existing aplets, which have been modified, with specific configurations. See "Creating new aplets based on existing aplets" on page 16-1.
- Downloaded from HP's Calculators web site.
- Copied from another calculator.

Aplets are stored in the Aplet library. See “Aplet library” on page 1-15 for further information.

You can modify configuration settings for the graphical, tabular, and symbolic views of the aplets in the following table. See “Aplet view configuration” on page 1-17 for further information.

Aplet name	**Use this aplet to explore:**
Function	Real-valued, rectangular functions *y* in terms of *x*. Example: $y = 2x^2 + 3x + 5$.
Inference	Confidence intervals and Hypothesis tests based on the Normal and Students-t distributions.
Parametric	Parametric relations *x* and *y* in terms of *t*. Example: $x = \cos(t)$ and $y = \sin(t)$.
Polar	Polar functions *r* in terms of an angle θ. Example: $r = 2\cos(4\theta)$.
Sequence	Sequence functions *U* in terms of *n*, or in terms of previous terms in the same or another sequence, such as U_{n-1} and U_{n-2} . Example: $U_1 = 0$, $U_2 = 1$ and $U_n = U_{n-2} + U_{n-1}$.
Solve	Equations in one or more real-valued variables. Example: $x + 1 = x^2 - x - 2$.
Statistics	One-variable (*x*) or two-variable (*x* and *y*) statistical data.

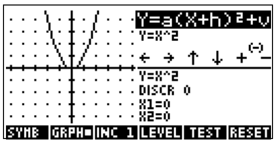
In addition to these aplets, which can be used in a variety of applications, the HP 39G/40G is supplied with two teaching aplets: Quad Explorer and Trig Explorer. You cannot modify configuration settings for these aplets.

A great many more teaching aplets can be found at HP’s web site and other web sites created by educators, together with accompanying documentation, often with student work sheets. These can be downloaded free of charge and transferred to the HP 39G/40G using the separately supplied Connectivity Kit.

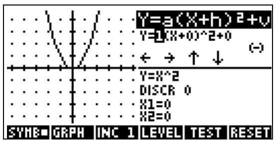
Quad Explorer aplet

The **Quad Explorer** aplet is used to investigate the behaviour of $y = a(x+h)^2 + v$ as the values of *a*, *h* and *v* change, both by manipulating the equation and seeing the change in the graph, *and* by manipulating the graph and seeing the change in the equation.

HINT More detailed documentation, and an accompanying student work sheet can be found at HP's web site.



When first started, the aplet is in GRPH mode, in which the arrow keys, the + and - keys and the (-) key are used to change the shape of the graph. This changing shape is reflected in the equation displayed at the top right corner of the screen, while the original graph is retained for comparison. In this mode the graph controls the equation.



It is also possible to have the equation control the graph. Pressing SYMB displays a sub-expression of your equation (see right).

Pressing the ► and ◄ key moves between sub-expressions, while pressing the ▲ and ▼ key changes their values.

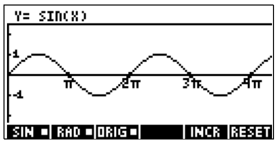
Pressing LEVEL allows the user to select whether all three sub-expressions will be explored at once or only one at a time.

A TEST button is provided to evaluate the student's knowledge. Pressing TEST displays a target quadratic graph. The student must manipulate the equation's parameters to make the equation match the target graph. When a student feels that they have correctly chosen the parameters a CHECK button evaluates the answer and provide feedback. An ANSW button is provided for those who give up!

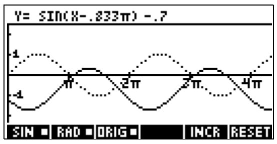
Trig Explorer aplet

The **Trig Explorer** aplet is used to investigate the behaviour of the graph of $y = a\sin(bx + c) + d$ as the values of *a, b, c* and *d* change, both by manipulating the equation and seeing the change in the graph, or by manipulating the graph and seeing the change in the equation.

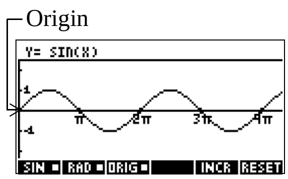
When the user presses START in the APLET view, the screen shown right is displayed.



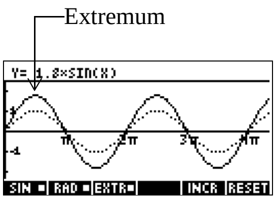
In this mode, the graph controls the equation. Pressing the ▲ ▼ and ◄ ► keys transforms the graph, with these transformations reflected in the equation.



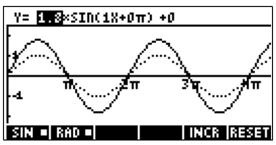
The button labelled ORIG is a toggle between ORIG and EXTR. When ORIG is chosen, the 'point of control' is at the origin (0,0) and the ▲ ▼ and ◄ ► keys control vertical and horizontal transformations. When EXTR is chosen the 'point of control' is on the first extremum of the graph (i.e. for the sine graph at $(\pi/2,1)$.



The arrow keys change the amplitude and frequency of the graph. This is most easily seen by experimenting.



Pressing SYMB displays the equation at the top of the screen. The equation is controls the graph. Pressing the ► and ◄ keys moves from parameter to parameter.



Pressing the ▲ or ▼ key changes the parameter's values.

The default angle setting for this aplet is radians. The angle setting can be changed to degrees by pressing RAD.

Aplet library

Aplets are stored in the Aplet library.

To open an aplet

Press [APLET] to display the Aplet library menu. Select the aplet and press **START** or [ENTER].

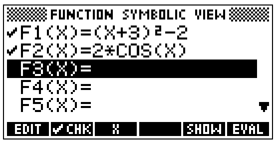
From within an aplet, you can return to HOME any time by pressing [HOME].

Aplet views

When you have configured an aplet to define the relation or data that you want to explore, you can display it in different views. Here are illustrations of the three major aplet views (Symbolic, Plot, and Numeric), the six supporting aplet views (from the VIEWS menu), and the two user-defined views (Note and Sketch).

Symbolic view

Press [SYMB] to display the aplet's Symbolic view.

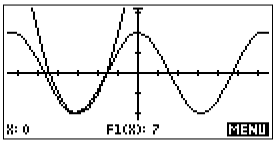


You use this view to define the function(s) or equation(s) that you want to explore.

See "About the Symbolic view" on page 2-1 for further information.

Plot view

Press [PLOT] to display the aplet's Plot view.

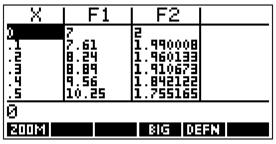


In this view, the functions that you have defined are displayed graphically.

See "About the Plot view" on page 2-5 for further information.

Numeric view

Press [NUM] to display the aplet's Numeric view.



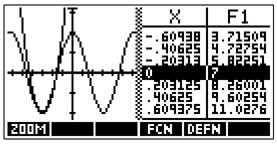
In this view, the functions that you have defined are displayed in tabular format.

See "About the numeric view" on page 2-15 for further information.

Plot-Table view

The VIEWS menu contains the Plot-Table view.

VIEWS
Select `Plot-Table` OK

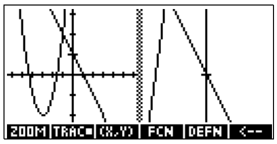


Splits the screen into the plot and the data table. See "Other views for scaling and splitting the graph" on page 2-13 for futher information.

Plot-Detail view

The VIEWS menu contains the Plot-Detail view.

VIEWS
Select `Plot-Detail` OK



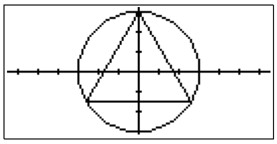
Splits the screen into the plot and a close-up.

See "Other views for scaling and splitting the graph" on page 2-13 for further information.

Overlay Plot view

The VIEWS menu contains the Overlay Plot view.

VIEWS
Select `Overlay Plot` OK



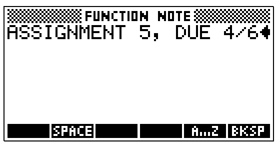
Plots the current expression(s) *without* erasing any pre-existing plot(s).

See "Other views for scaling and splitting the graph" on page 2-13 for further information.

Note view

Press SHIFT *NOTE* to display the aplet's note view.

This note is transferred with the aplet if it is sent to another calculator or to a PC. A note view contains text to supplement an aplet.



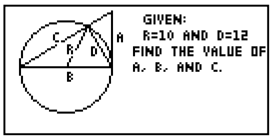
See "Notes and sketches" on page 14-1 for further information.

Sketch view

Press SHIFT *SKETCH* to display the aplet's sketch view.

Displays pictures to supplement an aplet.

See “Notes and sketches” on page 14-1 for further information.

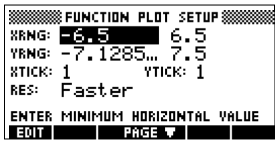


Aplet view configuration

You use the *SETUP* keys (SHIFT PLOT, and SHIFT NUM) to configure the aplet. For example, press SHIFT *SETUP-PLOT* (SHIFT PLOT)to display the input form for setting the aplet’s plot settings. Angle measure is controlled using the *MODES* view.

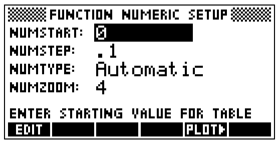
Plot Setup

Press SHIFT *SETUP-PLOT*. Sets parameters to plot a graph.



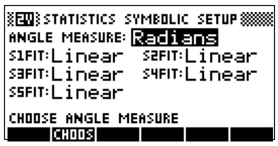
Numeric Setup

Press SHIFT *SETUP-NUM*. Sets parameters for building a table of numeric values.



Symbolic Setup

This view is only available in the Statistics aplet in 2VAR mode, where it plays an important role in choosing data models. Press (SHIFT *SETUP SYMB*.



To change views

Each view is a separate environment. To change a view, select a different view by pressing SYMB, NUM, PLOT keys or select a view from the VIEWS menu. To change to HOME, press HOME. You do not explicitly close the current view, you just enter another one—like passing from one room into another in a house. Data that you enter is automatically saved as you enter it.

To save aplet configuration

You can save an aplet configuration that you have used, and transfer the aplet to other HP 39G/40G calculators. See “Sending and receiving aplets” on page 16-5.

Mathematical calculations

The most commonly used math operations are available from the keyboard. Access to the rest of the math functions is via the MATH menu ([MATH]).

To access programming commands, press [SHIFT] *CMDS*. See “Programming commands” on page 15-14 for further information.

Where to start

The home base for the calculator is the HOME view ([HOME]). You can do all calculations here, and you can access all [MATH] operations.

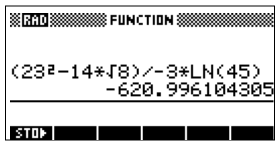
Entering expressions

- Enter an expression into the HP 39G/40G in the same left-to-right order that you would write the expression. This is called *algebraic entry.*
- To enter functions, select the key or MATH menu item for that function. You can also enter a function by using the Alpha keys to spell out its name.
- Press [ENTER] to evaluate the expression you have in the edit line (where the blinking cursor is). An *expression* can contain numbers, functions, and variables.

Example

Calculate $\frac{23^2 - 14\sqrt{8}}{-3}\ln(45)$:

[(] 23 [x²]
[-] 14
[X] [SHIFT] √ 8 [)]
[÷] [(-)] 3
[ln] 45 [)]
[ENTER]



Long results

If the result is too long to fit on the display line, or if you want to see an expression in textbook format, press [▲] to highlight it and then press **SHOW**.

Negative numbers

Type [(-)] to start a negative number or to insert a negative sign.

To raise a negative number to a power, enclose it in parentheses. For example, $(-5)^2 = 25$, whereas $-5^2 = -25$.

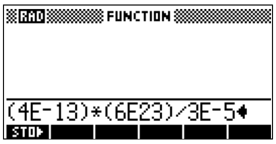
Scientific notation (powers of 10)

A number like 5×10^4 or 3.21×10^{-7} is written in *scientific notation*, that is, in terms of powers of ten. This is simpler to work with than 50000 or 0.000000321. To enter numbers like these, use *EEX*. (This is easier than using [X] 10 [x^y].)

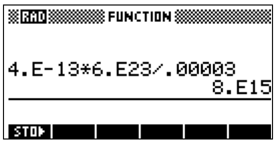
Example

Calculate $\frac{(4 \times 10^{-13})(6 \times 10^{23})}{3 \times 10^{-5}}$

[(] 4 [SHIFT] *EEX*
[(-)] 13 [)]
[X] [(] 6 [SHIFT] *EEX*
23 [)] [÷] 3 [SHIFT] *EEX*
[(-)] 5



[ENTER]



Explicit and implicit multiplication

Implied multiplication takes place when two operands appear with no operator in between. If you enter AB, for example, the result is `A*B`.

However, for clarity, it is better to include the multiplication sign where you expect multiplication in an expression. It is clearest to enter AB as `A*B`.

HINT Implied multiplication will not always work as expected. For example, entering `A(B+4)` will not give `A*(B+4)`. Instead an error message is displayed: "Invalid User Function". This is because the calculator interprets `A(B+4)` as meaning 'evaluate function A at the value B+4', and function A does not exist. When in doubt, insert the * sign manually.

Parentheses

You need to use parentheses to enclose arguments for functions, such as SIN(45). You can omit the final parenthesis at the end of an edit line. The calculator inserts it automatically.

Parentheses are also important in specifying the order of operation. *Without* parentheses, the HP 39G/40G calculates according to the order of *algebraic precedence* (the next topic). Following are some examples using parentheses.

Entering...	**Calculates...**
SIN 45 + SHIFT π	sin (45 + π)
SIN 45) + SHIFT π	sin (45) + π
SHIFT √ 85 X 9	$\sqrt{85} \times 9$
SHIFT √ (85 X 9)	$\sqrt{85 \times 9}$

Algebraic precedence order of evaluation

Functions within an expression are evaluated in the following order of precedence. Functions with the same precedence are evaluated in order from left to right.

1. Expressions within parentheses. Nested parentheses are evaluated from inner to outer.
2. Prefix functions, such as SIN and LOG.
3. Postfix functions, such as !
4. Power function, ^, NTHROOT.
5. Negation, multiplication, and division.
6. Addition and subtraction.
7. AND and NOT.
8. OR and XOR.
9. Left argument of | (where).
10. Equals, =.

Largest and smallest numbers

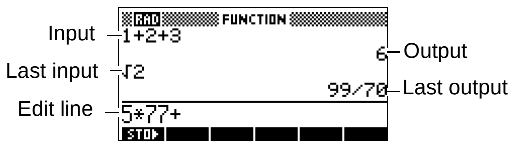
The smallest number the HP 39G/40G can represent is 1×10^{-499}(1E–499). A smaller result is displayed as zero. The largest number is $9.99999999999 \times 10^{-49}$. A larger result is still displayed as this number.

Clearing numbers

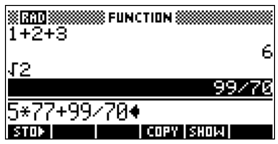
- DEL clears the character under the cursor. When the cursor is positioned after the last character, DEL deletes the character to the left of the cursor, that is, it performs the same as a backspace key.
- *CANCEL* (ON) clears the edit line.
- SHIFT *CLEAR* clears all input and output in the display, including the display history.

Using previous results

The HOME display (HOME) shows you four lines of input/ output history. An unlimited (except by memory) number of previous lines can be displayed by scrolling. You can retrieve and reuse any of these values or expressions.



When you highlight a previous input or result (by pressing ▲), the COPY and SHOW menu labels appear.



To copy a previous line

Highlight the line (press ▲) and press COPY. The number (or expression) is copied into the edit line.

To reuse the last result

Press SHIFT *ANS* (last answer) to put the last result from the HOME display into an expression. *ANS* is a variable that is updated each time you press ENTER.

To repeat a previous line

To repeat the very last line, just press ENTER. Otherwise, highlight the line (press ▲) first, and then press ENTER. The highlighted expression or number is re-entered. If the previous line is an expression containing the *ANS*, the calculation is repeated iteratively.

Example

See how SHIFT *ANS* retrieves and reuses the last result (50), and ENTER updates *ANS* (from 50 to 75 to 100).

50 ENTER + 25
ENTER ENTER

You can use the last result as the first expression in the edit line without pressing SHIFT *ANS*. Pressing +, -, X, or ÷, (or other operators that require a preceding argument) automatically enters *ANS* before the operator.

You can reuse any other expression or value in the HOME display by highlighting the expression (using the arrow keys), then pressing COPY. See "Using previous results" on page 1-21 for more details.

The variable *ANS* is different from the numbers in HOME's display history. A value in *ANS* is stored internally with the full precision of the calculated result, whereas the displayed numbers match the display mode.

HINT When you retrieve a number from *ANS*, you obtain the result to its full precision. When you retrieve a number from the HOME's display history, you obtain exactly what was displayed.

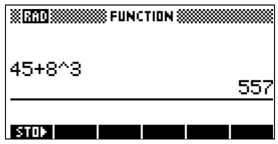
Pressing ENTER evaluates (or re-evaluates) the last input, whereas pressing SHIFT *ANS* copies the last result (as *ANS*) into the edit line.

Storing a value in a variable

You can save an answer in a variable and use the variable in later calculations. There are 27 variables available for storing real values. These are A to Z and θ. See Chapter 11, “Variables and memory management” for more information on variables. For example:

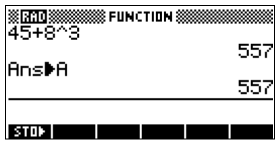
1. Perform a calculation.

   45 [+] 8 [x^y] 3
   [ENTER]



2. Store the result in the A variable.

   STO▶ [ALPHA] A [ENTER]



3. Perform another calculation using the A variable.

   95 [+] 2 [X] [ALPHA] A

Accessing the display history

Pressing [▲] enables the highlight bar in the display history. While the highlight bar is active, the following menu and keyboard keys are very useful:

Key	Function
[▲], [▼]	Scrolls through the display history.
COPY	Copies the highlighted expression to the position of the cursor in the edit line.
SHOW	Displays the current expression in standard mathematical form.
[DEL]	Deletes the highlighted expression from the display history, unless there is a cursor in the edit line.
[SHIFT] *CLEAR*	Clears all lines of display history and the edit line.

Clearing the display history

It's a good habit to clear the display history (SHIFT *CLEAR*) whenever you have finished working in HOME. It saves calculator memory to clear the display history. Remember that *all* your previous inputs and results are saved until you clear them.

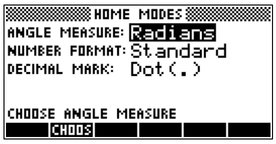
Using fractions

To work with fractions in HOME, you set the number format to Fractions, as follows:

Setting Fraction mode

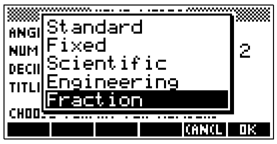
1. In HOME, open the HOME MODES input form.

   SHIFT *MODES*



2. Select Number Format and press CHOOS to display the options, then select Fraction.

   ▼ CHOOS ▼ ▼ ▼ ▼



3. Press OK to select the option, then select the precision value.

   OK ►

4. Enter the precision that you want to use, and press OK to set the precision. Press HOME to return to HOME.

   See "Setting fraction precision" below for more information.

Setting fraction precision

The fraction precision setting determines the precision in which the HP 39G/40G converts a decimal value to a fraction. The greater the precision value that is set, the closer the fraction is to the decimal value.

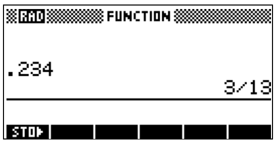
By choosing a precision of 1 you are saying that the fraction only has to match 0.234 to at least 1 decimal place (3/13 is 0.23076...).

The fractions used are found using the technique of continued fractions.

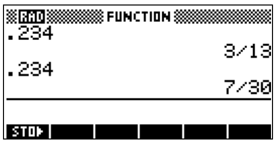
When converting recurring decimals this can be important. For example, at precision 6 the decimal 0.6666 becomes 3333/5000 (6666/10000) whereas at precision 3, 0.6666 becomes 2/3, which is probably what you would want.

For example, when converting .234 to a fraction, the precision value has the following effect:

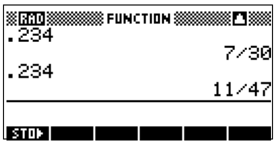
- Precision set to 1:



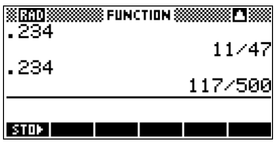
- Precision set to 2:



- Precision set to 3:



- Precision set to 4



Fraction calculations

When entering fractions:

- You use the [÷] key to separate the numerator part and the denominator part of the fraction.
- To enter a mixed fraction, for example, $1^1/_2$, you enter it in the format $(1+^1/_2)$.

For example, to perform the following calculation:

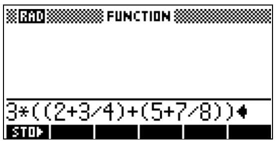
$3(2^3/_4 + 5^7/_8)$

1. Set the mode Number format to fraction.

   [SHIFT] *MODES* [▼]
   CHOOS *Select*
   `Fraction`
   [ENTER] [▶] 4 OK

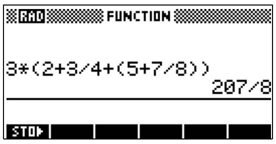
2. Return to HOME and enter the calculation.

   3 [X] [(] [(] 2 [+] 3
   [÷] 4 [)] [+] [(] 5 [+] 7
   [÷] 8 [)] [)]



3. Evaluate the calculation.

   [ENTER]



Converting decimals to fractions

To convert a decimal value to a fraction:

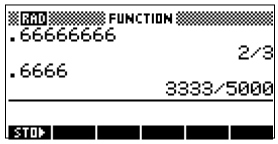
1. Set the number mode to Fraction.
2. Either retrieve the value from the History, or enter the value on the command line.
3. Press [ENTER] to convert the number to a fraction.

Converting a number to a fraction

When converting a number to a fraction, keep the following points in mind:

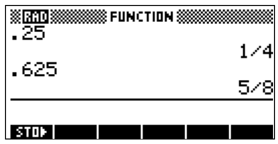
- When converting a recurring decimal to a fraction, set the fraction precision to about 6, and ensure that you include more than six decimal places in the recurring decimal that you enter.

  In this example, the fraction precision is set to 6. The top calculation returns the correct result. The bottom one does not.



- To convert an exact decimal to a fraction, set the fraction precision to at least two more than the number of decimal places in the decimal.

  In this example, the fraction precision is set to 6.



Complex numbers

Complex results

The HP 39G/40G can return a complex number as a result for some math functions. A complex number appears as an ordered pair (*x, y*), where *x* is the real part and *y* is the imaginary part. For example, entering $\sqrt{-1}$ returns (0,1).

To enter complex numbers

Enter the number in either of these forms, where *x* is the real part, *y* is the imaginary part, and *i* is the imaginary constant, $\sqrt{-1}$:

- *(x, y)* or
- *x + iy.*

To enter *i*:

- press SHIFT ALPHA I

  or

- press MATH, ▲ or ▼ keys to select `Constant`, ▶ to move to the right column of the menu, ▼ to select `i`, and OK.

Storing complex numbers

There are 10 variables available for storing complex numbers: Z0 to Z9. To store a complex number in a variable:

- Enter the complex number, press STO▶, enter the variable to store the number in and press ENTER.

  (4 , 5) STO▶
  ALPHA Z 0 ENTER

Catalogs and editors

The HP 39G/40G has several catalogs and editors. You use them to create and manipulate objects. They access features and stored values (numbers or text or other items) that are independent of aplets.

- A *catalog* lists items, which you can delete or transmit, for example an aplet.
- An *editor* lets you create or modify items and numbers, for example a note or a matrix.

Catalog/Editor	**Contents**
Aplet library (APLET)	Aplets.
Sketch editor (SHIFT *SKETCH*)	Sketches and diagrams, See Chapter 14, “Notes and sketches”.
List (SHIFT *LIST*)	Lists. In HOME, lists are enclosed in {}. See Chapter 13, “Lists”.
Matrix (SHIFT *MATRIX*)	One- and two-dimensional arrays. In HOME, arrays are enclosed in []. See Chapter 12, “Matrices”.
Notepad (SHIFT *NOTEPAD*)	Notes (short text entries). See Chapter 14, “Notes and sketches”.
Program (SHIFT *PROGRAM*)	Programs that you create, or associated with user-defined aplets. See Chapter 15, “Programming”.

Differences between the HP 38G and the HP 39G/40G

CAS

The HP 40G is packaged with a computer algebra system (CAS). Refer to the CAS Manual for further information.

Memory manager

The HP 39G/40G incorporates a memory manager that you can use to see how much memory the objects that you have created or loaded are occupying. See “Memory Manager” on page 11-9 for more information.

Plot Goto function

In Plot view, you can use the GOTO menu key to jump to a value on the plot instead of having to trace the plot to locate values. See “Exploring the graph” on page 2-7 for more information.

Statistics Pred function

When you choose the FIT option in the Statistics aplet’s Plot view screen, it is now possible to TRACE along the regression curve. Once a data set and regression curve is displayed, pressing the up and down arrows will move between the data and the curve of regression. When the regression curve is selected, the values displayed in the Plot view status line are the PREDY values. On the HP 38G, the Trace function would select known data points only.

Inference aplet

To complement the Statistics aplet, a new Inference aplet has been added. Use this aplet to perform hypothesis tests and determine confidence intervals. See “About the Inference aplet” on page 9-1 for more information.

Trig Explorer and Quadratic Explorer aplets

The teaching aplets Trig Explorer and Quadratic Explorer have been added to the calculator. These two aplets add powerfully to the capabilities of the calculator in the classroom.

2

Aplets and their views

Aplet views

This section examines the options and functionality of the three main views for the Function, Polar, Parametric, and Sequence aplets: Symbolic, Plot, and Numeric views.

About the Symbolic view

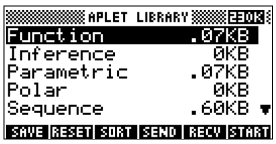
The Symbolic view is the *defining view* for the Function, Parametric, Polar, and Sequence aplets. The other views are derived from the symbolic expression.

You can create up to 10 different definitions for each Function, Parametric, Polar, and Sequence aplet. You can graph any of the relations (in the same aplet) simultaneously by selecting them.

Defining an expression (Symbolic view)

Choose the aplet from the Aplet Library.

APLET



Press ▲ or ▼ to select an aplet.

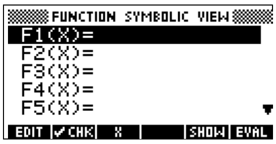
START

The Function, Parametric, Polar, and Sequence aplets start in the Symbolic view.

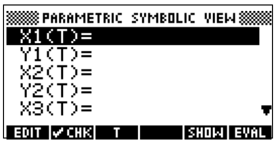
If the highlight is on an existing expression, scroll to an empty line—unless you don’t mind writing over the expression—or, clear one line (DEL) or all lines (SHIFT *CLEAR*).

Expressions are selected (check marked) on entry. To deselect an expression, press ✓CHK. All selected expressions are plotted.

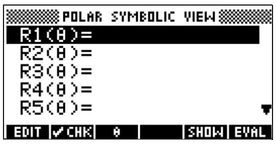
– **For a Function definition**, enter an expression to define *F(X)*. The only independent variable in the expression is *X*.



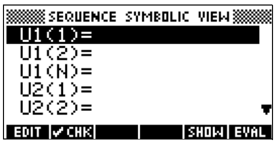
– **For a Parametric definition**, enter a pair of expressions to define *X(T)* and *Y(T)*. The only independent variable in the expressions is *T*.



– **For a Polar definition**, enter an expression to define *R*(θ). The only independent variable in the expression is θ.



– **For a Sequence definition**, either: Enter the first and second terms for *U (U1*, or...*U9, or U0*). Define the *n*th term of the sequence in terms of *N* or of the prior terms, *U(N–1) and U(N–2)*. The expressions should produce real-valued sequences with integer domains.Or define the *n*th term as a non-recursive expression in terms of *n* only. In this case, the calculator inserts the first two terms based on the expression that you define.



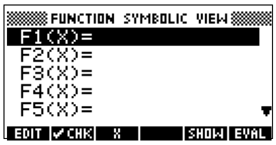
Evaluating expressions

In aplets

In the Symbolic view, a variable is a symbol only, and does not represent one specific value. To evaluate a function in Symbolic view, press EVAL. If a function calls another function, then EVAL resolves all references to other functions in terms of their independent variable.

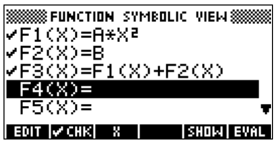
1. Choose the Function aplet.

   APLET
   Select `Function`
   START



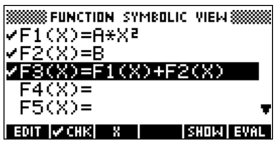
2. Enter the expressions in the Function aplet's Symbolic view.

   ALPHA A X *
   x^2 OK
   ALPHA B OK
   ALPHA F1 (X) +
   ALPHA F2 (X
) OK



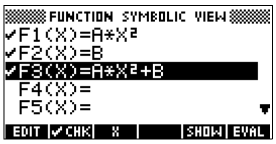
3. Highlight F3(X).

   ▲



4. Press EVAL

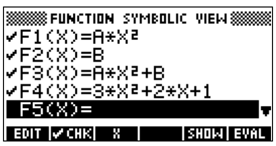
   Note how the values for F1(X) and F2(X) are substituted into F3(X).

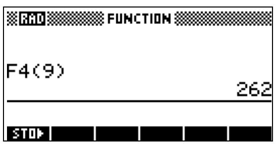


In HOME

You can also evaluate any expression in HOME by entering it into the edit line and pressing ENTER.

For example, define F4 as below. In HOME, type `F4(9)` and press ENTER. This evaluates the expression, substituting `9` in place of `X` into `F4`.





SYMB view keys

The following table details the menu keys that you use to work with the Symbolic view.

Key	Meaning
EDIT	Copies the highlighted expression to the edit line for editing. Press OK when done.
✓CHK	Checks/unchecks the current expression (or set of expressions). Only checked expression(s) are evaluated in the Plot and Numeric views.
X	Enters the independent variable in the Function aplet. Or, you can use the X,T,θ key on the keyboard.
T	Enters the independent variable in the Parametric aplet. Or, you can use the X,T,θ key on the keyboard.
θ	Enters the independent variable in the Polar aplet. Or, you can use the X,T,θ key on the keyboard.
N	Enters the independent variable in the Sequence aplet. Or, you can use the X,T,θ key on the keyboard.
SHOW	Displays the current expression in text book form.
EVAL	Resolves all references to other definitions in terms of variables and evaluates all arithmetic expressions.
VARS	Displays a menu for entering variable names or contents of variables.
MATH	Displays the menu for entering math operations.
SHIFT *CHARS*	Displays special characters. To enter one, place the cursor on it and press OK. To remain in the CHARS menu and enter another special character, press ECHO.
DEL	Deletes the highlighted expression or the current character in the edit line.
SHIFT *CLEAR*	Deletes all expressions in the list or clears the edit line.

About the Plot view

After entering and selecting (check marking) the expression in the Symbolic view, press PLOT. To adjust the appearance of the graph or the interval that is displayed, you can change the Plot view settings.

You can plot up to ten expressions at the same time. Select the expressions you want to be plotted together.

Setting up the plot (Plot view setup)

Press SHIFT *SETUP-PLOT* to define any of the settings shown in the next two tables.

1. Highlight the field to edit.
   - If there is a number to enter, type it in and press ENTER or OK.
   - If there is an option to choose, press CHOOS, highlight your choice, and press ENTER or OK. As a shortcut to CHOOS, just highlight the field to change and press + to cycle through the options.
   - If there is an option to select or deselect, press ✓CHK to check or uncheck it.
2. Press PAGE▼ to view more settings.
3. When done, press PLOT to view the new plot.

Plot view settings

The plot view settings are:

Field	Meaning
XRNG, YRNG	Specifies the minimum and maximum horizontal (X) and vertical (Y) values for the plotting window.
RES	For function plots: Resolution; “Faster” plots in alternate pixel columns; “Detail” plots in every pixel column.
TRNG	Parametric aplet: Specifies the t-values (T) for the graph.
θRNG	Polar aplet: Specifies the angle (θ) value range for the graph.

Field	Meaning (Continued)
NRNG	Sequence aplet: Specifies the index (N) values for the graph.
TSTEP	For Parametric plots: the increment for the independent variable.
θSTEP	For Polar plots: the increment value for the independent variable.
SEQPLOT	For Sequence aplet: Stairstep or Cobweb types.
XTICK	Horizontal spacing for tickmarks.
YTICK	Vertical spacing for tickmarks.

Those items with space for a checkmark are settings you can turn on or off. Press PAGE▼ to display the second page.

Field	Meaning
SIMULT	If more than one relation is being plotted, plots them simultaneously (otherwise sequentially).
INV. CROSS	Cursor crosshairs invert the status of the pixels they cover.
CONNECT	Connect the plotted points. (The Sequence aplet always connects them.)
LABELS	Label the axes with XRNG and YRNG values.
AXES	Draw the axes.
GRID	Draw grid points using XTICK and YTICK spacing.

Reset plot settings

To reset the default values for all plot settings, press SHIFT *CLEAR* in the Plot Setup view. To reset the default value for a field, highlight the field, and press DEL.

Exploring the graph

Plot view gives you a selection of keys and menu keys to explore a graph further. The options vary from aplet to aplet.

PLOT view keys

The following table details the keys that you use to work with the graph.

Key	Meaning
SHIFT *CLEAR*	Erases the plot and axes.
VIEWS	Offers additional pre-defined views for splitting the screen and for scaling (“zooming”) the axes.
SHIFT ◄ SHIFT ►	Moves cursor to *far left* or *far right.*
▲ ▼	Moves cursor between relations.
PAUSE or ON	Interrupts plotting.
CONT	Continues plotting if interrupted.
MENU	Turns menu-key labels on and off. When the labels are off, pressing MENU turns them back on. • Pressing MENU once displays the full row of labels. • Pressing MENU a second time removes the row of labels to display only the graph. • Pressing MENU a third time displays the coordinate mode.
ZOOM	Displays ZOOM menu list.
TRACE	Turns trace mode on/off. A white box appears over the E on TRACE.
GOTO	Opens an input form for you to enter an *X* (or *T* or *N* or θ) value. Enter the value and press OK. The cursor jumps to the point on the graph that you entered.
FCN	Function aplet only: Turns on menu list for root-finding functions (*see* “Analyse graph with FCN functions” on page 3-3.
DEFN	Displays the current, *defining* expression. Press MENU to restore the menu.

Trace a graph

You can trace along a function using the ◄ or ► key which moves the cursor along the graph. The display also shows the current coordinate position (*x*, *y*) of the cursor. Trace mode and the coordinate display are automatically set when a plot is drawn.

Note: Tracing might not appear to exactly follow your plot if the resolution (in Plot Setup view) is set to Faster. This is because RES: FASTER plots in only every other column, whereas tracing always uses every column.

In Function and Sequence Aplets: You can also scroll (move the cursor) left or right beyond the edge of the display window in trace mode, giving you a view of more of the plot.

To move between relations

If there is more than one relation displayed, press ▲ or ▼ to move between relations.

To jump directly to a value

To jump straight to a value rather than using the Trace function, use the GOTO menu key. Press GOTO, then enter a value. Press OK to jump to the value.

To turn trace on/ off

If the menu labels are not displayed, press MENU first.

- Turn off trace mode by pressing TRACE■.
- Turn on trace mode by pressing TRACE.
- To turn the coordinate display off, press MENU.

Zoom within a graph

One of the menu key options is ZOOM. Zooming redraws the plot on a larger or smaller scale. It is a shortcut for changing the Plot Setup.

With the Set Factors option you can specify the factors that determine the extent of zooming, and whether the zoom is centered about the cursor.

ZOOM options

Press ZOOM, select an option, and press OK. (If ZOOM is not displayed, press MENU.) Not all ZOOM options are available in all aplets.

Option	Meaning
`Center`	Re-centers the plot around the current position of the cursor *without* changing the scale.
`Box...`	Lets you draw a box to zoom in on. See “Other views for scaling and splitting the graph” on page 2-13.

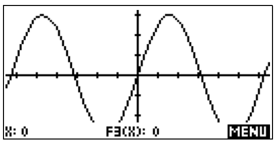
Option	Meaning (Continued)
In	Divides horizontal and vertical scales by the X-factor and Y-factor. For instance, if zoom factors are 4, then zooming in results in 1/4 as many units depicted per pixel. (see Set Factors)
Out	Multiplies horizontal and vertical scales by the X-factor and Y-factor (see Set Factors).
X-Zoom In	Divides horizontal scale only, using X–factor.
X-Zoom Out	Multiplies horizontal scale, using X–factor.
Y-Zoom In	Divides vertical scale only, using Y–factor.
Y-Zoom Out	Multiplies vertical scale only, using Y–factor.
Square	Changes the vertical scale to match the horizontal scale. (Use this after doing a Box Zoom, X–Zoom, or Y–Zoom.)
Set Factors...	Sets the X–Zoom and Y–Zoom factors for zooming. Includes option to recenter the plot before zooming.
Auto Scale	Rescales the vertical axis so that the display shows a representative piece of the plot, for the supplied *x* axis settings. (For Sequence and Statistics aplets, autoscaling rescales both axes.) The autoscale process uses the first selected function only to determine the best scale to use.
Decimal	Rescales both axes so each pixel = 0.1 units. Resets default values for XRNG (–6.5 to 6.5) and YRNG (–3.1 to 3.2). (Not in Sequence or Statistics aplets.)

Option	Meaning (Continued)
`Integer`	Rescales horizontal axis only, making each pixel =1 unit. (Not available in Sequence or Statistics aplets.)
`Trig`	Rescales horizontal axis so 1 pixel = π/24 radian, 7.58, or $8^{1}/_{3}$ grads; rescales vertical axis so 1 pixel = 0.1 unit. (Not in Sequence or Statistics aplets.)
`Un-zoom`	Returns the display to the previous zoom, or if there has been only one zoom, un-zoom displays the graph with the original plot settings.

ZOOM examples

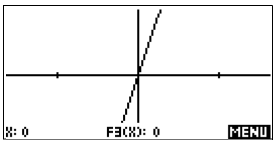
The following screens show the effects of zooming options on a plot of $3\sin x$.

Plot of $3\sin x$



Zoom In:

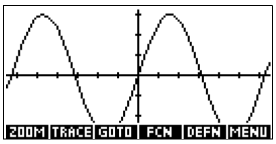
MENU **ZOOM** `In` **OK**



Un-zoom:

ZOOM `Un-zoom` **OK**

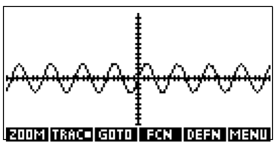
(Press ▲ *to move to the bottom of the Zoom list.)*



Zoom Out:

ZOOM `Out` **OK**

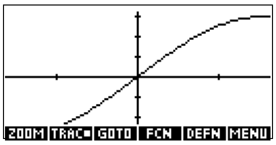
Now un-zoom.



X-Zoom In:

ZOOM `X-Zoom In` OK

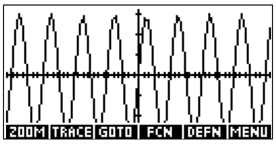
Now un-zoom.



X-Zoom Out:

ZOOM `X-Zoom Out` OK

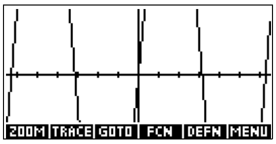
Now un-zoom.



Y-Zoom In:

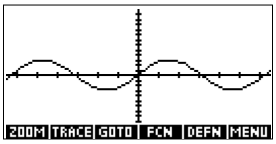
ZOOM `Y-Zoom In` OK

Now un-zoom.



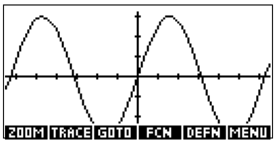
Y-Zoom Out:

ZOOM `Y-Zoom Out` OK



Zoom Square:

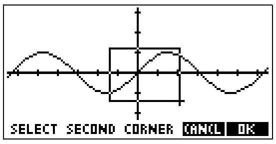
ZOOM `Square` OK



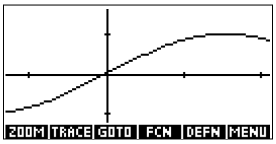
To box zoom

The Box Zoom option lets you draw a box around the area you want to zoom in on by selecting the endpoints of one diagonal of the zoom rectangle.

1. If necessary, press **MENU** to turn on the menu-key labels.
2. Press **ZOOM** and select **BOX**.
3. Position the cursor on one corner of the rectangle. Press **OK**.
4. Use the cursor keys (▼, etc.) to drag to the opposite corner.



5. Press **OK** to zoom in on the boxed area.



To set zoom factors

1. In the Plot view, press **MENU**.
2. Press **ZOOM**.
3. Select `Set Factors...` and press **OK**.
4. Enter the zoom factors. There is one zoom factor for the horizontal scale (`XZOOM`) and one for the vertical scale (`YZOOM`).

   Zooming out *multiplies* the scale by the factor, so that a greater scale distance appears on the screen. Zooming in *divides* the scale by the factor, so that a shorter scale distance appears on the screen.

Other views for scaling and splitting the graph

The preset viewing options menu (VIEWS) contains options for drawing the plot using certain pre-defined configurations. This is a shortcut for changing Plot view settings. For instance, if you have defined a trigonometric function, then you could select `Trig` to plot your function on a trigonometric scale. It also contains split-screen options.

In certain aplets, for example those that you download from the world wide web, the preset viewing options menu can also contain options that relate to the aplet.

VIEWS menu options

Press VIEWS, select an option, and press **OK**.

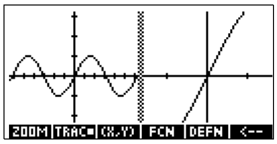
Option	Meaning
`Plot-Detail`	Splits the screen into the plot and a close-up.
`Plot-Table`	Splits the screen into the plot and the data table.
`Overlay Plot`	Plots the current expression(s) *without* erasing any pre-existing plot(s).
`Auto Scale`	Rescales the vertical axis so that the display shows a representative piece of the plot, for the supplied *x* axis settings. (For Sequence and Statistics aplets, autoscaling rescales both axes.) The autoscale process uses the first selected function only to determine the best scale to use.
`Decimal`	Rescales both axes so each pixel = 0.1 unit. Resets default values for `XRNG` (–6.5 to 6.5) and `YRNG` (–3.1 to 3.2). (Not in Sequence or Statistics aplets.)
`Integer`	Rescales horizontal axis only, making each pixel=1 unit. (Not available in Sequence or Statistics aplets.)
`Trig`	Rescales horizontal axis so 1 pixel=π/24 radian, 7.58, or $8^1/_3$ grads; rescales vertical axis so 1 pixel = 0.1 unit. (Not in Sequence or Statistics aplets.)

Split the screen

The Plot-Detail view can give you two simultaneous views of the plot.

1. Press VIEWS. Select `Plot-Detail` and press **OK**. The graph is plotted twice. You can now zoom in on the right side.
2. Press **MENU** **ZOOM**, select the zoom method and press **OK** or ENTER. This zooms the right side. Here is an example of split screen with `Zoom In`.

.



   – The Plot menu keys are available as for the full plot (for tracing, coordinate display, equation display, and so on).

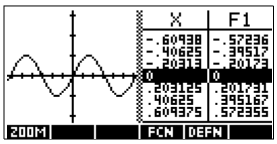
   – SHIFT ◄ moves the leftmost cursor to the screen's left edge and SHIFT ► moves the rightmost cursor to the screen's right edge.

   – The **<--** menu key copies the right plot to the left plot.

3. To un-split the screen, press PLOT. The left side takes over the whole screen.

The Plot-Table view gives you two simultaneous views of the plot.

1. Press VIEWS. Select `Plot-Table` and press **OK**. The screen displays the plot on the left side and a table of numbers on the right side.



2. To move up and down the table, use the ◄ and ► cursor keys. These keys move the trace point left or right along the plot, and in the table, the corresponding values are highlighted.
3. To move between functions, use the ▲ and ▼ cursor keys to move the cursor from one graph to another.
4. To return to a full Numeric (or Plot) view, press NUM (or PLOT).

Overlay plots

If you want to plot over an existing plot *without erasing* that plot, then use VIEWS `Overlay Plot` instead of PLOT. Note that tracing follows only the current functions from the current aplet.

Decimal scaling

Decimal scaling is the default scaling. If you have changed the scaling to Trig or Integer, you can change it back with Decimal.

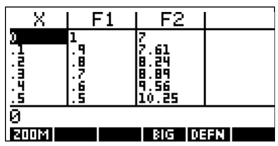
Integer scaling

Integer scaling compresses the axes so that each pixel is 1×1 and the origin is near the screen center.

Trigonometric scaling

Use trigonometric scaling whenever you are plotting an expression that includes trigonometric functions. Trigonometric plots are more likely to intersect the axis at points factored by π.

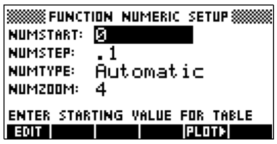
About the numeric view



After entering and selecting (check marking) the expression or expressions that you want to explore in the Symbolic view, press NUM to view a table of data values for the independent variable (X, T, θ, or N) and dependent variables.

Setting up the table (numeric view setup)

Press SHIFT *NUM* to define any of the table settings. Use the Numeric Setup input form to configure the table.



1. Highlight the field to edit. Use the arrow keys to move from field to field.
   - If there is a number to enter, type it in and press ENTER or **OK**. To modify an existing number, press **EDIT**.
   - If there is an option to choose, press **CHOOS**, highlight your choice, and press ENTER or **OK**.
   - **Shortcut:** Press the **PLOT►** key to copy values from the Plot Setup into `NUMSTART` and `NUMSTEP`. Effectively, the **PLOT►** menu key allows you to make the table match the pixel columns in the graph view.
2. When done, press NUM to view the table of numbers.

Numeric view settings

The following table details the fields on the Numeric Setup input form.

Field	Meaning
NUMSTART	The independent variable's starting value.
NUMSTEP	The size of the increment from one independent variable value to the next.
NUMTYPE	Type of numeric table: Automatic or Build Your Own. To build your own table, you must type each independent value into the table yourself.
NUMZOOM	Allows you to zoom in or out on a selected value of the independent variable.

Reset numeric settings

To reset the default values for all table settings, press SHIFT *CLEAR*.

Exploring the table of numbers

NUM view menu keys

The following table details the menu keys that you use to work with the table of numbers.

Key	Meaning
ZOOM	Displays ZOOM menu list.
BIG	Toggles between two character sizes.
DEFN	Displays the *defining* function expression for the highlighted column. To cancel this display, press DEFN.

Zoom within a table

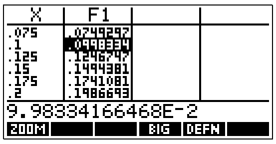
Zooming redraws the table of numbers in greater or lesser detail.

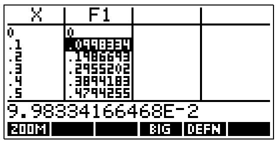
ZOOM options

The following table lists the zoom options:

Option	Meaning
`In`	Decreases the intervals for the independent variable so a narrower range is shown. Uses the `NUMZOOM` factor in Numeric Setup.
`Out`	Increases the intervals for the independent variable so that a wider range is shown. Uses the `NUMZOOM` factor in Numeric Setup.
`Decimal`	Changes intervals for the independent variable to 0.1 units. Starts at zero. (Shortcut to changing `NUMSTART` and `NUMSTEP`.)
`Integer`	Changes intervals for the independent variable to 1 unit. Starts at zero. (Shortcut to changing `NUMSTEP`.)
`Trig`	Changes intervals for independent variable to $\pi/24$ radian or 7.5 degrees or $8^1/_3$ grads. Starts at zero.
`Un-zoom`	Returns the display to the previous zoom.

The display on the right is a Zoom In of the display on the left. The `ZOOM` factor is 4.





HINT To jump to an independent variable value in the table, use the arrow keys to place the cursor in the independent variable column, then enter the value to jump to.

Automatic recalculation

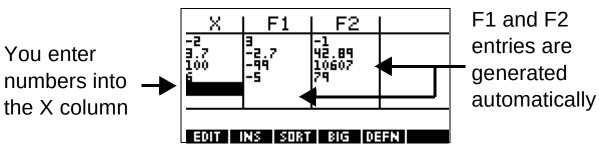
You can enter any new value in the *X* column. When you press ENTER, the values for the dependent variables are recalculated, and the entire table is regenerated with the same interval between *X* values.

Building your own table of numbers

The default `NUMTYPE` is "Automatic", which fills the table with data for regular intervals of the independent (*X*, *T*, θ, or *N*) variable. With the `NUMTYPE` option set to "Build Your Own", you fill the table yourself by typing in the independent-variable values you want. The dependent values are then calculated and displayed.

Build a table

1. Start with an expression defined (in Symbolic view) in the aplet of your choice. *Note: Function, Polar, Parametric, and Sequence aplets only.*
2. In the Numeric Setup (SHIFT *NUM*), choose `NUMTYPE: Build Your Own`.
3. Open the Numeric view (NUM).
4. Clear existing data in the table (SHIFT *CLEAR*).
5. Enter the independent values in the left-hand column. Type in a number and press ENTER. You do not have to enter them in order, because the **SORT** function can rearrange them. To insert a number between two others, use **INS**.



Clear data

Press SHIFT *CLEAR*, YES to erase the data from a table.

"Build Your Own" menu keys

Key	Meaning
EDIT	Puts the highlighted independent value (*X*, *T*, θ, or *N*) into the edit line. Pressing ENTER replaces this variable with its current value.
INS	Inserts a row of zero values at the position of the highlight. Replace a zero by typing the number you want and pressing ENTER.
SORT	Sorts the independent variable values into ascending or descending order. Press SORT and select the ascending or descending option from the menu, and press OK.
BIG	Toggles between two character sizes.
DEFN	Displays the defining function expression for the highlighted column.
DEL	Deletes the highlighted row.
SHIFT *CLEAR*	Clears *all* data from the table.

Example: plotting a circle

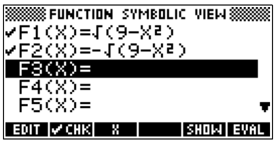
Plot the circle, $x^2 + y^2 = 9$. First rearrange it to read $y = \pm\sqrt{9 - x^2}$.

To plot both the positive and negative y values, you need to define two equations as follows:

$y = \sqrt{9 - x^2}$ and $y = -\sqrt{9 - x^2}$

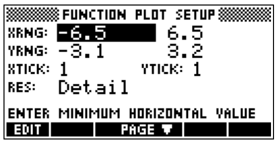
1. In the Function aplet, specify the functions.

   [APLET] *Select* `Function` START
   [SHIFT] √ [(] 9
   [–] [X,T,θ] [X²] [)] [ENTER]
   [(–)] [SHIFT] √ [(] 9
   [–] [X,T,θ]
   [X²] [)] [ENTER]



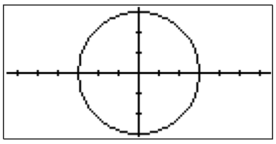
2. Reset the graph setup to the default settings.

   [SHIFT] *SETUP-PLOT*
   [SHIFT] *CLEAR*



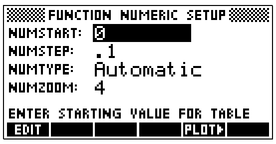
3. Plot the two functions and hide the menu so that you can see all the circle.

   [PLOT] MENU MENU



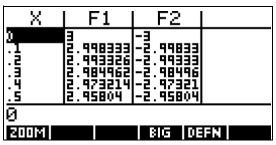
4. Reset the numeric setup to the default settings.

   [SHIFT] *SETUP-NUM*
   [SHIFT] *CLEAR*



5. Display the functions in numeric form.

   [NUM]



Function aplet

About the Function aplet

The Function aplet enables you to explore up to 10 real–valued, rectangular functions *y* in terms of *x*. For example $y = 2x + 3$.

Once you have defined a function you can:

- create graphs to find roots, intercepts, slope, signed area, and extrema
- create tables to evaluate functions at particular values.

This chapter demonstrates the basic tools of the Function aplet by stepping you through an example. See "Aplet views" on page 2-1 for further information about the functionality of the Symbolic, Numeric, and Plot views.

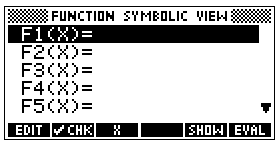
Getting started with the Function aplet

The following example involves two functions: a linear function $y = 1 - x$ and a quadratic equation $y = (x+3)^2 - 2$.

Open the Function aplet

1. Open the Function aplet.

   APLET *Select* `Function`
   START

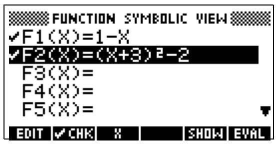
   The Function aplet starts in the Symbolic view.

   The Symbolic view is the *defining view* for Function, Parametric, Polar, and Sequence aplets. The other views are derived from the symbolic expression.

Define the expressions

2. There are 10 function definition fields on the Function aplet's Symbolic view screen. They are labeled F1(X) to F0(X). Highlight the function definition field you want to use, and enter an expression. (You can press [DEL] to delete an existing line, or [SHIFT] *CLEAR* to clear all lines.)

   1 [-] [X,T,θ] [ENTER]
   [(] [X,T,θ] [+] 3 [)] [X²]
   [-] 2 [ENTER]

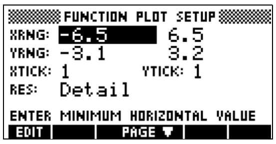


Set up the plot

You can change the scales of the *x* and *y* axes, graph resolution, and spacing of axis ticks.

3. Display plot settings.

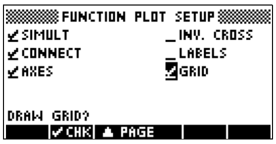
   [SHIFT] *SETUP-PLOT*



   Note: For our example, you can leave the plot settings at their default values since we will be using the Auto Scale feature to choose an appropriate y axis for our x axis settings. If your settings do not match this example, press [SHIFT] *CLEAR to restore the default values.*

4. Specify a grid for the graph.

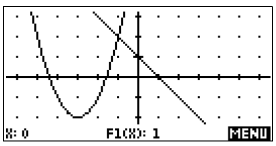
   PAGE ▼
   [▶] [▼] [▼] ✔CHK



Plot the functions

5. Plot the functions.

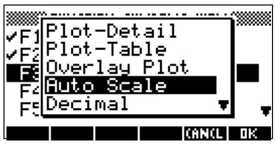
   [PLOT]

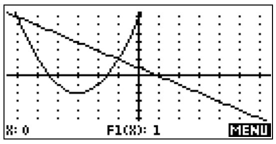


Change the scale

6. You can change the scale to see more or less of your graphs. In this example, choose Auto Scale. (See “VIEWS menu options” on page 2-13 for a description of Auto Scale).

   VIEWS *Select* `Auto Scale` OK

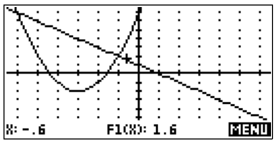




Trace a graph

7. Trace the linear function.

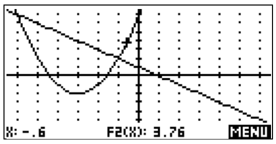
   ◄ *6 times*



Note: By default, the tracer is active.

8. Jump from the linear function to the quadratic function.

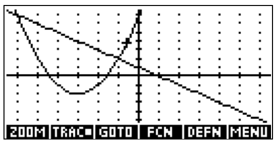
   ▲



Analyse graph with FCN functions

9. Display the Plot view menu.

   MENU



From the Plot view menu, you can use the functions on the FCN menu to find roots, intersections, slopes, and areas for a function defined in the Function aplet (and any Function-based aplets). The FCN functions act on the currently selected graph. See “FCN functions” on page 3-9 for further information.

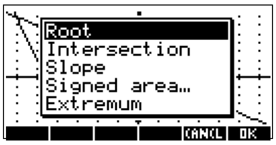
To find the greater of the two roots of the quadratic function

10. Find the greater of the two roots of the quadratic function.

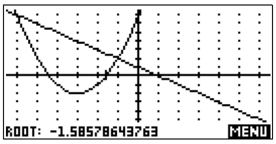
    Note: Move the cursor to the graph of the quadratic equation by pressing the ▲ or ▼ *key. Then move the cursor so that it is near* $x = -1$ *by pressing the* ► *or* ◄ *key.*

    FCN *Select* `Root`

    OK



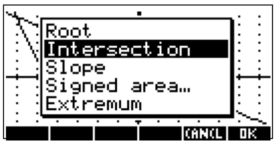
The root value is displayed at the bottom of the screen.



To find the intersection of the two functions

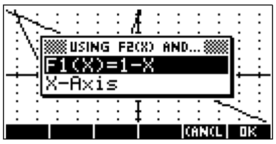
11. Find the intersection of the two functions.

    MENU FCN ▼ OK

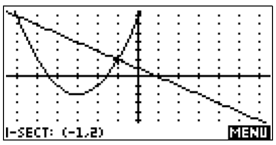


12. Choose the linear function whose intersection with the quadratic function you wish to find.

    OK



The coordinates of the intersection point are displayed at the bottom of the screen.



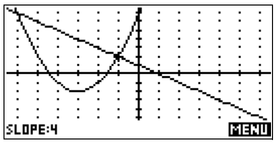
Note: If there is more than one intersection (as in our example), the coordinates of the intersection point closest to the current cursor position are displayed.

To find the slope of the quadratic function

13. Find the slope of the quadratic function at the intersection point.

    MENU FCN
    Select `Slope`
    OK

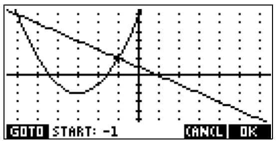
    The slope value is displayed at the bottom of the screen.



To find the signed area of the two functions

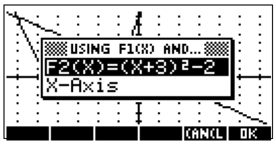
14. To find the area between the two functions in the range $-2 \le x \le -1$, first move the cursor to $F1(x) = 1 - x$ and select the signed area option.

    MENU FCN
    Select `Signed area`
    OK



15. Move the cursor to $x = -1$ by pressing the ▶ or ◀ key.

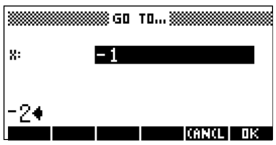
    OK



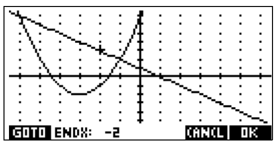
16. Press OK to accept using $F2(x) = (x + 3)^2 - 2$ as the other boundary for the integral.

17. Choose the end value for x.

    GOTO
    (-) 2
    OK



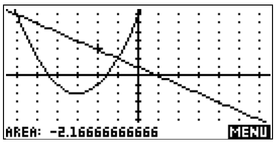
    The cursor jumps to $x = -2$ on the linear function.



18. Display the numerical value of the integral.

    OK

    Note: See “Shading area” on page 3-10 for another method of calculating area.

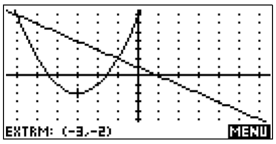


To find the extremum of the quadratic

19. Move the cursor to the quadratic equation and find the extremum of the quadratic.

    ▲ **MENU** **FCN**
    Select `Extremum` **OK**

    The coordinates of the extremum are displayed at the bottom of the screen.

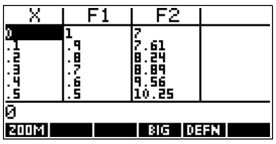


HINT The Root and Extremum functions return one value only even if the function has more than one root or extremum. The function finds the value closest to the position of the cursor. You need to re-locate the cursor to find other roots or extrema that may exist.

Display the numeric view

20. Display the numeric view.

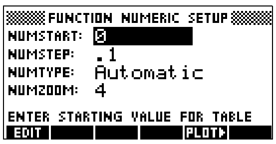
    NUM



Set up the table

21. Display the numeric setup.

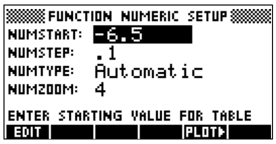
    SHIFT *SETUP-NUM*



See “Setting up the table (numeric view setup)” on page 2-16 for more information.

22. Match the table settings to the pixel columns in the graph view.

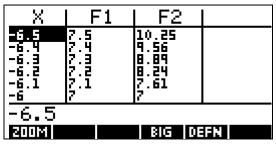
PLOT OK



Explore the table

23. Display a table of numeric values.

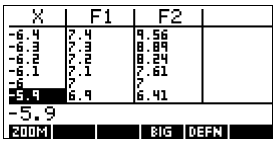
NUM



To navigate around a table

24. Move to X = –5.9.

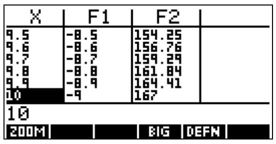
▼ *6 times*



To go directly to a value

25. Move directly to X = 10.

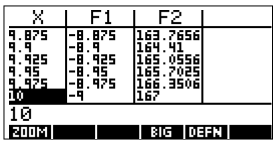
1 0 OK



To access the zoom options

26. Zoom in on X = 10 by a factor of 4. *Note:* `NUMZOOM` *has a setting of 4.*

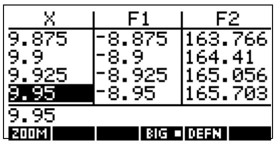
ZOOM `In`
OK



To change font size

27. Display table numbers in large font.

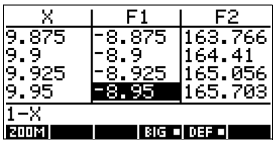
    BIG



To display the symbolic definition of a column

28. Display the symbolic definition for the F1 column.

    ▶ DEFN



The symbolic definition of F1 is displayed at the bottom of the screen.

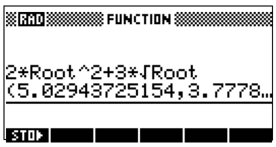
Function aplet interactive analysis

From the Plot view (PLOT), you can use the functions on the FCN menu to find roots, intersections, slopes, and areas for a function defined in the Function aplet (and any Function-based aplets). See “FCN functions” on page 3-9. The FCN operations act on the currently selected graph.

The results of the FCN functions are saved in the following variables:

- AREA
- EXTREMUM
- ISECT
- ROOT
- SLOPE

For example, if you use the ROOT function to find the root of a plot, you can use the result in calculations in Home.

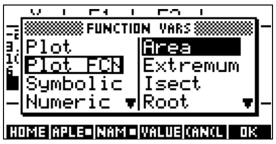


Access FCN variables

The FCN variables are contained in the VARS menu.

To access FCN variables in HOME:

VARS APLET
Select `Plot FCN`
▶
▲ or ▼ to choose a variable OK



To access FCN variable in the Function aplet's Symbolic view:

VARS
Select `Plot FCN`
▶
▲ or ▼ to choose a variable
OK

FCN functions

The FCN functions are:

Function	**Description**
`Root`	Select `Root` to find the root of the current function nearest the cursor. If no root is found, but only an extremum, then the result is labeled `EXTR:` instead of `ROOT:`. (The root-finder is also used in the Solve aplet. See also "Interpreting results" on page 7-6.) The cursor is moved to the root value on the x-axis and the resulting *x*-value is saved in a variable named ROOT.
`Extremum`	Select `Extremum` to find the maximum or minimum of the current function nearest the cursor. This displays the coordinate values and moves the cursor to the extremum. The resulting value is saved in a variable named EXTREMUM.
`Slope`	Select `Slope` to find the numeric derivative at the current position of the cursor. The result is saved in a variable named SLOPE.

Function	Description (Continued)
`Signed area`	Select `Signed area` to find the numeric integral. (If there are two or more expressions checkmarked, then you will be asked to choose the second expression from a list that includes the *x*-axis.) Select a starting point, then move the cursor to selection ending point. The result is saved in a variable named AREA.
`Intersection`	Select `Intersection` to find the intersection of two graphs nearest the cursor. *(You need to have at least two selected expressions in Symbolic view.)* Displays the coordinate values and moves the cursor to the intersection. (Uses Solve function.) The resulting *x*-value is saved in a variable named ISECT.

Shading area

You can shade a selected area between functions. This process also gives you an approximate measurement of the area shaded.

1. Open the Function aplet. The Function aplet opens in the Symbolic view.
2. Select the expressions whose curves you want to study.
3. Press PLOT to plot the functions.
4. Press ◄ or ► to position the cursor at the starting point of the area you want to shade.
5. Press MENU.
6. Press FCN, then select `Signed area` and press OK.
7. Press OK, choose the function that will act as the boundary of he shaded area, and press OK.
8. Press the ◄ or ► key to shade in the area.
9. Press OK to calculate the area. The area measurement is displayed near the bottom of the screen.

To remove the shading, press PLOT to re-draw the plot.

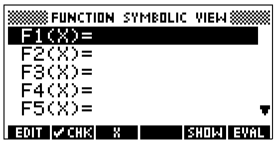
Plotting a piecewise defined function example

Suppose you wanted to graph the following piecewise defined function.

$$f(x) = \begin{cases} x + 2 & ;x \le -1 \\ x^2 & ;-1 < x \le 1 \\ 4 - x & ;x \ge 1 \end{cases}$$

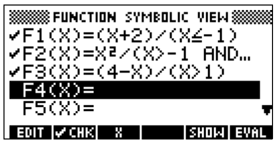
1. Open the Function aplet.

   [APLET] *Select* `Function` START

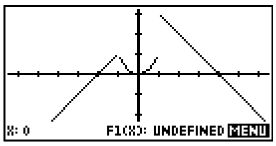


2. Highlight the line you want to use, and enter the expression. (You can press [DEL] to delete an existing line, or [SHIFT] *CLEAR* to clear all lines.)

   [(] X [+] 2 [)] [÷]
   [(] X [SHIFT] *CHARS* ≤
   [(-)] 1 [)] [ENTER]
   X [x²] [÷] [(] X
   [SHIFT] *CHARS* > [(-)] 1
   [SHIFT] *AND* X
   [SHIFT] *CHARS* ≤ 1 [)] [ENTER]
   [(] 4 [-] X [)] [÷] [(] X
   [SHIFT] *CHARS* > 1 [)] [ENTER]



   Note: You can use the X *menu key to assist in the entry of equations. It has the same effect as pressing* [X,T,θ].



4

Parametric aplet

About the Parametric aplet

The Parametric aplet allows you to explore parametric equations. These are equations in which both *x* and *y* are defined as functions of *t*. They take the forms $x = f(t)$ and $y = g(t)$.

Getting started with the Parametric aplet

The following example uses the parametric equations

$x(t) = 3\sin t$
$y(t) = 3\cos t$

Note: This example will produce a circle. For this example to work, the angle measure must be set to degrees.

Open the Parametric aplet

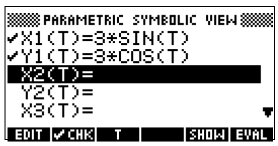
1. Open the Parametric aplet.

   APLET *Select* `Parametric`
   START

Define the expressions

2. Enter each equation.

   3 X SIN X,T,θ)
   ENTER
   3 X COS X,T,θ)
   ENTER



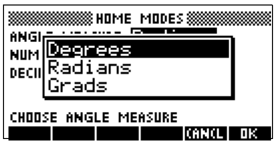
Set angle measure

3. Set the angle measure to degrees.

   SHIFT *MODES*

   CHOOS

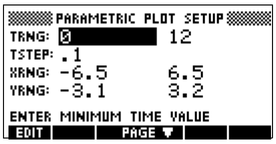
   Select `Degrees` OK



Set up the plot

4. Display the graphing options.

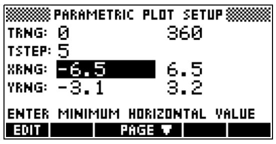
   SHIFT *PLOT*



   You can see the Plot Setup input form has two fields not included in the Function aplet, `TRNG` and `TSTEP`. `TRNG` specifies the range of *t* values. `TSTEP` specifies the step value between *t* values.

5. Set the `TRNG` and `TSTEP` so that *t* steps from 0° to 360° in 5° steps.

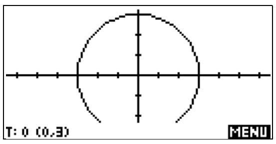
   ▶ 360 OK
   5 OK



Plot the expression

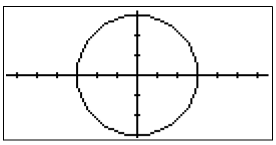
6. Plot the expression.

   PLOT



7. To see all the circle, press MENU twice.

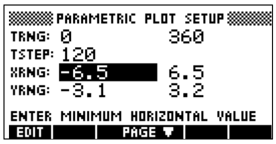
   MENU MENU



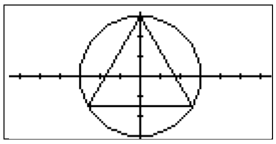
Overlay plot

8. Plot a triangle graph over the existing circle graph.

   SHIFT *PLOT*
   ▼
   120 OK



   VIEWS
   Select `Overlay Plot`
   OK
   MENU MENU



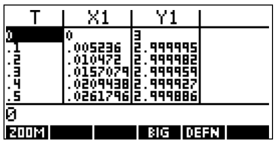
   A triangle is displayed rather than a circle (without changing the equation) because the changed value of `TSTEP` ensures that points being plotted are 120° apart instead of nearly continuous.

   You are able to explore the graph using trace, zoom, split screen, and scaling functionality available in the Function aplet. See “Exploring the graph” on page 2-7 for further information.

Display the numbers

9. Display the table of numeric values.

   NUM



   You can see there is a column of *t*-values.

   This column is active in the sense that you can highlight a *t*-value, type in a replacement value, and see the table jump to that value. You can also zoom in or zoom out on any *t*-value in the table.

   You are able to explore the table using ZOOM, GOTO, build your own table, and split screen functionality available in the Function aplet. See “Exploring the table of numbers” on page 2-18 for further information.

Polar aplet

Getting started with the polar aplet

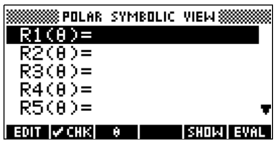
Open the Polar aplet

1. Open the Polar aplet.

   APLET *Select* `Polar`

   RESET YES START

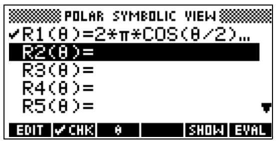
   Like the Function aplet, the Polar aplet opens in the Symbolic view.



Define the expression

2. Define the polar equation $r = 2\pi\cos(\theta/2)\cos(\theta)^2$.

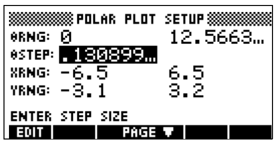
   2 SHIFT π COS
   X,T,θ ÷ 2)
   COS X,T,θ)
   x² ENTER



Specify plot settings

3. Specify the plot settings. In this example, we will use the default settings, except for the `θRNG` fields.

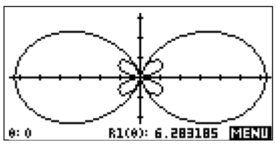
   SHIFT *SETUP-PLOT*
   SHIFT *CLEAR*
   ▶ 4 SHIFT π OK



Plot the expression

4. Plot the expression.

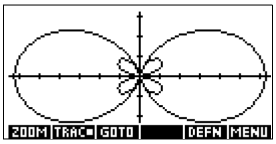
   PLOT



Explore the graph

5. Display the Plot view menu key labels.

   MENU

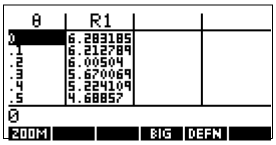
   

   The Plot view options available are the same as those found in the Function aplet. See “Exploring the graph” on page 2-7 for further information.

Display the numbers

6. Display the table of values θ for and R1.

   NUM

   The Numeric view options available are the same as those found in the Function aplet. See “Exploring the table of numbers” on page 2-18 for further information.

6

Sequence aplet

About the Sequence aplet

The Sequence aplet allows you to explore sequences.

You can define a sequence named, for example, U1:

- in terms of *n*
- in terms of U1(*n*-1)
- in terms of U1(*n*-2)
- in terms of another sequence, for example, U2(*n*)
- in any combination of the above.

Getting started with the Sequence aplet

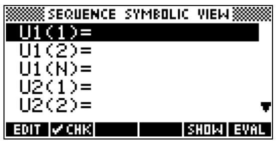
The following example defines and then plots an expression in the Sequence aplet.

Open the Sequence aplet

1. Open the Sequence aplet.

   APLET *Select* `Sequence` START

   The Sequence aplet starts in the Symbolic view.



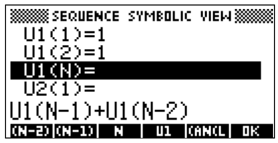
Define the expression

2. Define the Fibonacci sequence, in which each term (after the first two) is the sum of the preceding two terms:

   $U_1 = 1$, $U_2 = 1$, $U_n = U_{n-1} + U_{n-2}$ for $n > 3$.

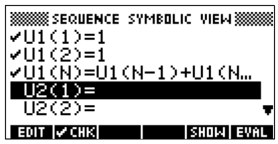
   In the Symbolic view of the Sequence aplet, highlight the U1(1) field and begin defining your sequence.

   1 ENTER 1 ENTER
   U1 (N-1) + U1
   (N-2)

   Note: You can use the N, U1, and U2 menu keys to assist in the entry of equations.

   ENTER

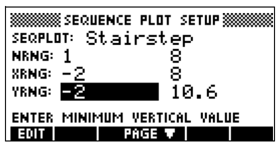
Specify plot settings

3. In Plot Setup, first set the `SEQPLOT` option to `Stairstep`. Reset the default plot settings by clearing the Plot Setup view.

   – A **Stairsteps** graph plots *n* on the horizontal axis and U_n on the vertical axis.

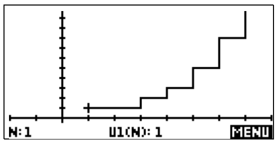
   – A **Cobweb** graph plots U_{n-1} on the horizontal axis and U_n on the vertical axis.

   SHIFT *SETUP-PLOT*
   SHIFT *CLEAR*
   ▼ ▶ 8 ENTER
   ▶ 8 ENTER

Plot the sequence

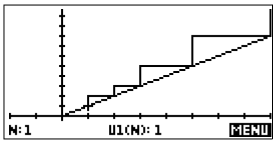
4. Plot the Fibonacci sequence.
   [PLOT]



5. In Plot Setup, set the `SEQPLOT` option to `Cobweb`.

   [SHIFT] *SETUP-PLOT*
   CHOOS *Select* `Cobweb`
   OK

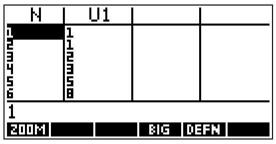
   [PLOT]



Display the table

6. Display the table of numeric values for this example.

   [NUM]



7

Solve aplet

About the Solve aplet

The Solve aplet solves an equation or an expression for its *unknown variable*. You define an equation or expression in the symbolic view, then supply values for all the variables *except one* in the numeric view. Solve works only with real numbers.

Note the differences between an equation and an expression:

- An *equation* contains an equals sign. Its solution is a value for the unknown variable that makes both sides have the same value.
- An *expression* does not contain an equals sign. Its solution is a *root*, that is, a value for the unknown variable that makes the expression have a value of zero.

You can use the Solve aplet to solve an equation for any one of its variables.

When the Solve aplet is started, it opens in the Solve symbolic view.

- In Symbolic view, you specify the expression or equation to solve. You can define up to ten equations (or expressions), named E0 to E9. Each equation can contain up to 27 real variables, named A to Z and θ.
- In Numeric view, you specify the values of the known variables, highlight the variable that you want to solve for, and press SOLVE.

You can solve the equation as many times as you want, using new values for the knowns and highlighting a different unknown.

Note: It is not possible to solve for more than one variable at once. Simultaneous linear equations, for example, should be solved using matrices or graphs in the Function aplet.

Getting started with the Solve aplet

Suppose you want to find the acceleration needed to increase the speed of a car from 16.67 m/sec (60 kph) to 27.78 m/sec (100 kph) in a distance of 100 m.

The equation to solve is:

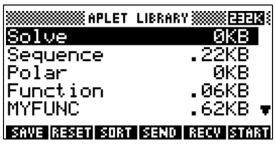
$$v^2 = u^2 + 2ad$$

Open the Solve aplet

1. Open the Solve aplet.

   [APLET] *Select* `Solve`
   START

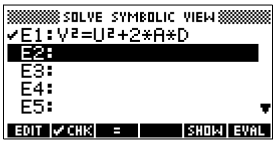
   The Solve aplet starts in the Symbolic view.



Define the equation

2. Define the equation.

   [ALPHA] V [X²]
   [ALPHA] U [X²]
   [+] 2 [x]
   [ALPHA] A [x]
   [ALPHA] D [ENTER]

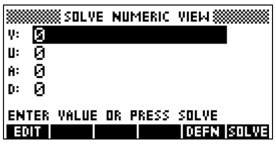


   Note: You can use the menu key to assist in the entry of equations.

Define known variables

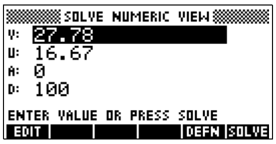
3. Display the Solve numeric view screen.

   [NUM]



4. Enter the values for the known variables.

   2 7 [.] 7 8 [ENTER]
   1 6 [.] 6 7 [ENTER]
   [▼]
   1 0 0 [ENTER]

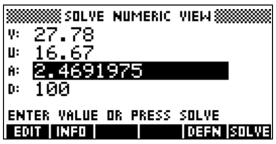


HINT If the Decimal Mark setting in the Modes input form ([SHIFT] *MODES*)is set to Comma, use [,] instead of [.].

Solve the unknown variable

5. Solve for the unknown variable (A).

   ▼ ▼ **SOLVE**



Therefore, the acceleration needed to increase the speed of a car from 16.67 m/sec (60 kph) to 27.78 m/sec (100 kph) in a distance of 100 m is approximately 2.47 m/s^2.

Because the variable A in the equation is linear, once values are substituted into V, U and D, we know that we need not look for any other solutions.

Plot the equation

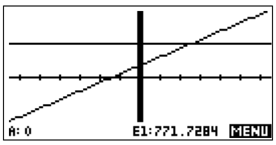
The Plot view shows one graph for each member of the selected equation. You can choose any of the variables in the Numeric view to be the independent variable.

The other variables take on the values assigned to them in the Numeric view. The current equation is $V^2 = U^2 + 2AD$. With the variable A highlighted, the Plot view will show two graphs.

One of these is $Y = V^2$, with $V = 27.78$, or $Y = 771.7284$. This graph will be a horizontal line. The other graph will be $Y = U^2 + 2AD$, with $U = 16.67$ and $D = 100$, or $Y = 200A + 277.8889$. This graph is also a line. The desired solution is the value of A where these two lines intersect.

6. Plot the equation for variable A.

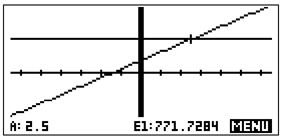
   VIEWS *Select* `Auto Scale`
   OK



7. Trace along the graph representing the left member of the equation until the cursor nears the intersection.

   ▶ *≈20 times*

   Note the value of A displayed near the bottom left corner of the screen.



   The Plot view provides a convenient way to find an approximation to a solution before using the Numeric view Solve option. See “Plotting to find guesses” on page 7-8 for more information.

Solve aplet’s NUM view keys

The Solve aplet’s NUM view keys are:

Key	Meaning
EDIT	Copies the highlighted value to the edit line for editing. Press OK when done.
INFO	Displays a message about the solution (see “Interpreting results” on page 7-6).
PAGE	Displays other pages of variables, if any.
DEFN	Displays the symbolic definition of the current expression. Press OK when done.
SOLVE	Finds a solution for the highlighted variable, based on the values of the other variables.
DEL	Clears highlighted variable to zero *or* deletes current character in edit line, if edit line is active.
SHIFT *CLEAR*	Resets all variable values to zero *or* clears the edit line, if cursor is in edit line.

Use an initial guess

You can usually obtain a faster and more accurate solution if you supply an estimated value for the unknown variable *before* pressing SOLVE. Solve starts looking for a solution at the initial guess.

Before plotting, make sure the unknown variable is highlighted in the numeric view. Plot the equation to help you select an initial guess when you don't know the range in which to look for the solution. See "Plotting to find guesses" on page 7-8 for further information.

HINT An initial guess is especially important in the case of a curve that could have more than one solution. In this case, only the solution closest to the initial guess is returned.

Number format

You can change the number format for the Solve aplet in the Numeric Setup view. The options are the same as in Home MODES: Standard, Fixed, Scientific, and Engineering. For the latter three, you also specify how many digits of accuracy you want. See "Mode settings" on page 1-9 for more information.

You might find it handy to set a different number format for the Solve aplet if, for example, you define equations to solve for the value of money. A number format of `Fixed 2` would be appropriate in this case.

Interpreting results

After Solve has returned a solution, press INFO in the Numeric view for more information. You will see one of the following three messages. Press OK to clear the message.

Message	Condition
Zero	The Solve aplet found a point where the value of the equation (or the root of the expression) is zero within the calculator's 12-digit accuracy.
Sign Reversal	Solve found two points where the value of the equation has opposite signs, but it cannot find a point in between where the value is zero. This might be because *either* the two points are neighbours (they differ by one in the twelfth digit), *or* the equation is not real-valued between the two points. Solve returns the point where the value is closer to zero. If the value of the equation is a continuous real function, this point is Solve's best approximation of an actual root.
Extremum	Solve found a point where the value of the equation approximates a local minimum (for positive values) or maximum (for negative values). This point may or may not be a root. *Or:* Solve stopped searching at 9.99999999999E499, the largest number the calculator can represent.

If Solve could not find a solution, you will see one of the following two messages.

Message	Condition
Bad Guess(es)	The initial guess lies outside the domain of the equation. Therefore, the solution was not a real number or it caused an error.
Constant?	The value of the equation is the same at every point sampled.

HINT It is important to check the information relating to the solve process. For example, the solution that the Solve aplet finds is not a solution, but the closest that the function gets to zero. Only by checking the information will you know that this is the case.

The Root-Finder at work

You can watch the process of the root-finder calculating and searching for a root. Immediately after pressing SOLVE to start the root-finder, press any key except ON. You will see two intermediate guesses and, to the left, the sign of the expression evaluated at each guess. For example:

+ 2 2.219330555745
– 1 21.31111111149

You can watch as the root-finder either finds a sign reversal or converges on a local extrema or does not converge at all. If there is no convergence in process, you might want to cancel the operation (press ON) and start over with a different initial guess.

Plotting to find guesses

The main reason for plotting in the Solve aplet is to help you find initial guesses and solutions for those equations that have difficult-to-find or multiple solutions.

Consider the equation of motion for an accelerating body:

$$x = v_0 t + \frac{at^2}{2}$$

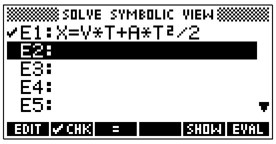
where x is distance, v_0 is initial velocity, t is time, and a is acceleration. This is actually *two* equations, $y = x$ and $y = v_0\, t + (at^2) / 2$.

Since this equation is quadratic for t, there can be both a positive and a negative solution. However, we are concerned only with positive solutions, since only positive distance makes sense.

1. Select the Solve aplet and enter the equation.

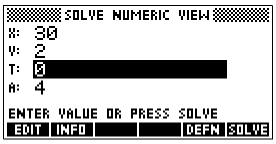
   APLET *Select* `Solve` START

   ALPHA X =
   ALPHA V X ALPHA T
   + ALPHA A
   X ALPHA T X² ÷ 2
   OK



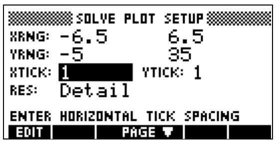
2. Find the solution for T (time) when X=30, V=2, and A=4. Enter the values for X, V, and A; then highlight the independent variable, T.

   NUM
   30 ENTER
   2 ENTER
   ▼ 4 ENTER
   ▼ ▼ *to highlight T*



3. Use the Plot view to find an initial guess for *T*. First set appropriate X and Y ranges in the Plot Setup. Since we have an equation, $X = V \times T + A \times T^2 / 2$, the plot will produce two graphs: one for $Y = X$ and one for $Y = V \times T + A \times T^2 / 2$. Since we have set $X = 30$ in this example, one of the graphs will be $Y = 30$. Therefore, make the YRNG –5 to 35. Keep the XRNG default of –6.5 to 6.5.

   SHIFT *SETUP-PLOT*
   ▼ (-)5 ENTER
   35 ENTER

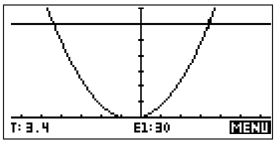


4. Plot the graph.

   PLOT

5. Move the cursor near the positive (right-side) intersection. This cursor value will be an initial guess for *T*.

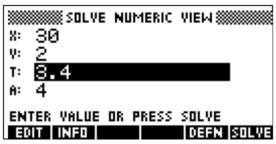
   ► *to move cursor to the intersection.*



   The two points of intersection show that there are two solutions for this equation. However, only positive values for *x* make sense, so we want to find the solution for the intersection on the right side of the *y*-axis.

6. Return to the Numeric view.

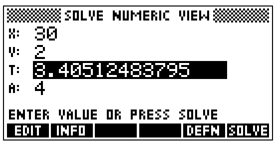
   NUM



   Note: the T-value is filled in with the position of the cursor from the Plot view.

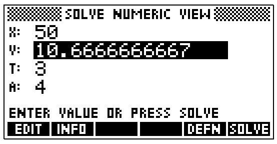
7. Ensure that the *T* value is highlighted, and solve the equation.

   SOLVE



8. Use this equation to solve for another variable, such as velocity. How fast must a body's initial velocity be in order for it to travel 50 m within 3 seconds? Assume the same acceleration, 4 m/s^2. *Leave the last value of V as an initial guess.*

   3 ENTER ▲ ▲ ▲
   50 ENTER
   SOLVE



Using variables in equations

You can use any of the real variable names, A to Z and θ. Do not use variable names defined for other types, such as M1 (a matrix variable).

Home variables

All home variables (other than those for aplet settings, like `Xmin` and `Ytick`) are *global*, which means they are *shared* throughout the different aplets of the calculator. A value that is assigned to a home variable anywhere remains with that variable wherever its name is used.

Therefore, if you have defined a value for *T* (as in the above example) in another aplet or even another Solve equation, that value shows up in the Numeric view for this Solve equation. When you then redefine the value for *T* in this Solve equation, that value is applied to *T* in all other contexts (until it is changed again).

This sharing allows you to work on the same problem in different places (such as HOME and the Solve aplet) without having to update the value everywhere whenever it is recalculated.

HINT As the Solve aplet uses any existing variable values, be sure to check for existing variable values that may affect the solve process. (You can use SHIFT *CLEAR* to reset all values to zero in the Solve aplet's Numeric view if you wish.)

Aplet variables

Functions defined in other aplets can also be referenced in the Solve aplet. For example, if, in the Function aplet, you define `F1(X)=X`^{2}`+10`, you can enter `F1(X)=50` in the Solve aplet to solve the equation `X`^{2}`+10=50`.

8

Statistics aplet

About the Statistics aplet

The Statistics aplet can store up to ten separate data sets at one time. It can do one-variable or two-variable statistical analysis of one or more sets of data.

The Statistics aplet starts with the Numeric view which is used to enter data. The Symbolic view is used to specify which columns contain data and which column contains frequencies.

You can also compute statistics values in HOME and recall the values of specific statistics variables.

The values computed in the Statistics aplet are saved in variables, and many of these variables are listed by the STATS function accessible from the Statistics aplet's Numeric view screen.

Getting started with the Statistics aplet

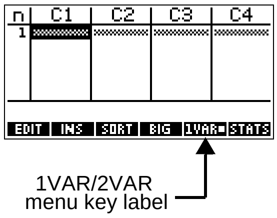
The following example asks you to enter and analyze the advertising and sales data (in the table below), compute statistics, fit a curve to the data, and predict the effect of more advertising on sales.

Advertising minutes (independent, *x*)	**Resulting Sales ($) (dependent, *y*)**
2	1400
1	920
3	1100
5	2265
5	2890
4	2200

Open the Statistics aplet

1. Open the Statistics aplet and clear existing data by pressing **RESET**.

   [APLET]
   Select `Statistics`
   RESET **YES**
   START

   The Statistics aplet starts in the Numerical view.

   At any time the Statistics aplet is configured for only one of two types of statistical explorations: one-variable (**1VAR**) or two-variable (**2VAR**). The 5th menu key label in the Numeric view toggles between these two options and shows the current option.

2. Select **2VAR**.

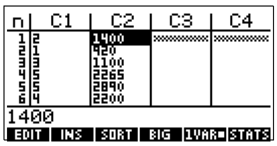
   You need to select **2VAR** because in this example we are analyzing a dataset comprising two variables: advertising minutes and resulting sales.

Enter data

3. Enter the data into the columns.

   2 [ENTER] 1 [ENTER]
   3 [ENTER] 5 [ENTER]
   5 [ENTER] 4 [ENTER]

   [▶] *to move to the next column*

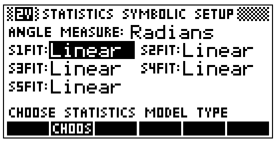
   

   1400 [ENTER] 920 [ENTER]
   1100 [ENTER] 2265 [ENTER]
   2890 [ENTER] 2200 [ENTER]

Choose fit and data columns

4. Select a fit in the Symbolic setup view.

   SHIFT *SETUP-SYMB*
   ▼ CHOOS
   Select `Linear`
   OK

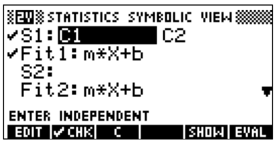


   You can define up to five explorations of two-variable data, named `S1` to `S5`. In this example, we will create just one: `S1`.

5. Specify the columns that hold the data you want to analyze.

   SYMB

   You could have entered your data into columns other than C1 and C2.

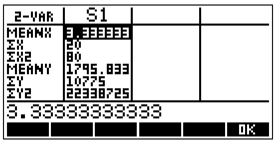


Explore statistics

6. Find the mean advertising time (`MEANX`) and the mean sales (`MEANY`).

   NUM STATS

   `MEANX` is about 3.3 minutes and `MEANY` is about $1796.

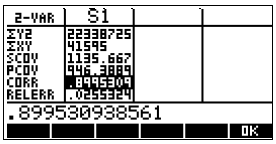


7. Scroll down to display the value for the correlation coefficient (`CORR`). The `CORR` value indicates how well the linear model fits the data.

   ▼ *9 times*

   The value is 0.8995 to four significant digits.

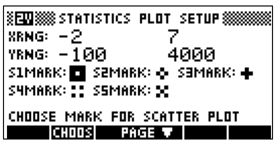
   OK



Setup plot

8. Change the plotting range to ensure all the data points are plotted (and select a different point mark, if you wish).

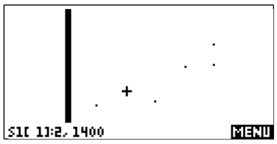
   SHIFT *SETUP-PLOT*
   ▶ 7 ENTER
   (-) 100 ENTER
   4000 ENTER



Plot the graph

9. Plot the graph.

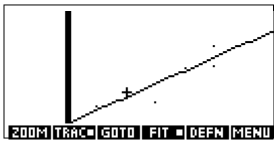
   PLOT



Draw the regression curve

10. Draw the regression curve (a curve to fit the data points).

    MENU **FIT**

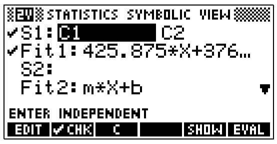


This draws the regression line for the best linear fit.

Display the equation for best linear fit

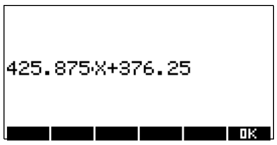
11. Return to the Symbolic view.

    SYMB



12. Display the equation for the best linear fit.

    ▼ *to move to the* FIT1 *field*
    SHOW

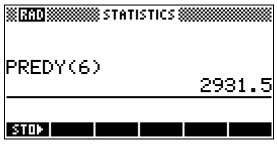


The full FIT1 expression is shown. The slope (m) is 425.875.
The *y*-intercept (b) is about 376.25.

Predict values

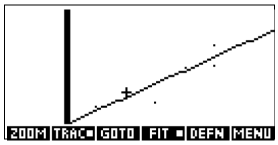
13. To find the predicted sales figure if advertising were to go up to 6 minutes:

    OK [HOME]
    [MATH] S (*to highlight* `Stat-Two`)
    [▶] [▼] *(to highlight* `PREDY`)
    OK 6 [ENTER]



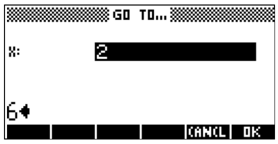
14. Return to the Plot view.

    [PLOT]



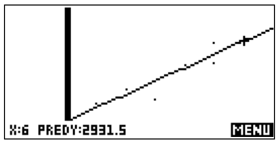
15. Jump to the indicated point on the regression line.

    [▼] **GOTO**
    6



OK

Observe the predicted *y*-value in the left bottom corner of the screen.



Entering and editing statistical data

The Numeric view ([NUM]) is used to enter data into the Statistics aplet. Each column represents a variable named C0 to C9. After entering the data, you must define the data set in the Symbolic view ([SYMB]).

HINT A data column must have at least four data points to provide valid two-variable statistics, or two data points for one-variable statistics.

You can also store statistical data values by copying lists from HOME into Statistics data columns. For example, in HOME, `L1` **STO▸** `C1` stores a copy of the list `L1` into the data-column variable `C1`.

Statistics aplet's NUM view keys

The Statistics aplet's Numeric view keys are:

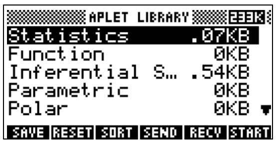
Key	**Meaning**
EDIT	Copies the highlighted item into the edit line.
INS	Inserts a zero value above the highlighted cell.
SORT	Sorts the specified *independent* data column in ascending or descending order, and rearranges a specified dependent (or frequency) data column accordingly.
BIG	Switches between larger and smaller font sizes.
1VAR■ 2VAR■	A toggle switch to select one-variable or two-variable statistics. This setting affects the statistical calculations and plots. The label indicates which setting is current.
STATS	Computes descriptive statistics for each data set specified in Symbolic view.
DEL	Deletes the currently highlighted value.
SHIFT *CLEAR*	Clears the current column or all columns of data. Press SHIFT *CLEAR* to display a menu list, then select the current column or all columns option, and press OK.
SHIFT *cursor key*	Moves to the first or last row, or first or last column.

Example

You are measuring the height of students in a classroom to find the mean height. The first five students have the following measurements 160cm, 165cm, 170cm, 175cm, 180cm.

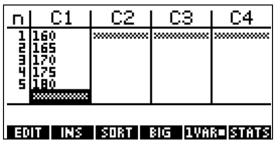
1. Open the Statistics aplet.

   APLET *Select* `Statistics`
   RESET YES
   START

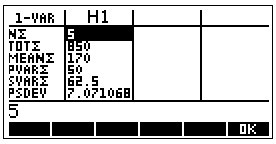


2. Enter the measurement data.

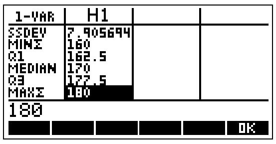
   160 ENTER
   165 ENTER
   170 ENTER
   175 ENTER
   180 ENTER



3. Find the mean of the sample.

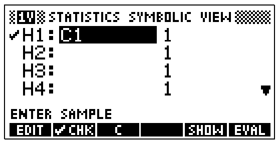


   Ensure the 1VAR / 2VAR menu key label reads 1VAR. Press STATS to see the statistics calculated from the sample data in C1. Press the ▼ key to scroll to further statistics.



   Note that the title for the column of statistics is H1. There are 5 data set definitions available for one-variable statistics: H1–H5. If data is entered in C1, H1 is automatically set to use C1 for data, and the frequency of each data point is set to 1. You can select other columns of data from the Statistics Symbolic setup view.

4. Press OK to close the statistics window and press SYMB key to see the data set definitions.



The first column indicates the associated column of data for each data set definition, and the second column indicates the constant frequency, or the column that holds the frequencies.

The keys you can use from this window are:

Key	**Meaning**
EDIT	Copies the column variable (or variable expression) to the edit line for editing. Press OK when done.
✓CHK	Checks/unchecks the current data set. Only the checkmarked data set(s) are computed and plotted.
C or S	Typing aid for the column variables (C) or for the Fit expressions (S).
SHOW	Displays the current variable expression in standard mathematical form. Press OK when done.
EVAL	Evaluates the variables in the highlighted column (C1, etc.) expression.
VARS	Displays the menu for entering variable names or contents of variables.
MATH	Displays the menu for entering math operations.
DEL	Deletes the highlighted variable *or* the current character in the edit line.

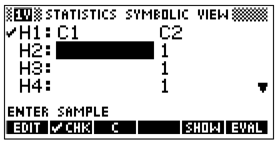
Key	Meaning (Continued)
SHIFT *CLEAR*	Resets default specifications for the data sets *or* clears the edit line (if it was active). *Note: If* SHIFT *CLEAR is used the data sets will need to be selected again before re-use.*

To continue our example, suppose that the heights of the rest of the students in the class are measured, but each one is rounded to the nearest of the five values first recorded. Instead of entering all the new data in C1, we shall simply add another column, C2, that holds the frequencies of our five data points in C1.

Height (cm)	Frequency
160	5
165	3
170	8
175	2
180	1

5. Move the highlight bar into the right column of the H1 definition and replace the frequency value of 1 with the name C2.

   C 2

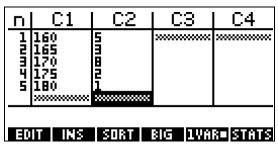


6. Return to the numeric view.

   NUM

7. Enter the frequency data shown in the above table.

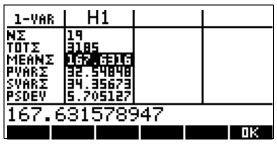
   ▶ 5 ENTER
   3 ENTER
   8 ENTER
   2 ENTER
   1 ENTER



8. Display the computed statistics.

   STATS

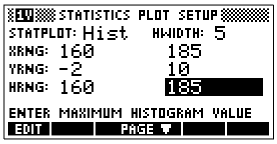
   You can scroll down to the mean. The mean height is approximately 167.63cm.



9. Setup a histogram plot for the data.

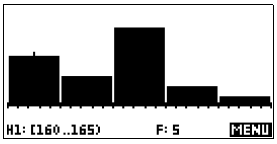
   OK [SHIFT] *SETUP-PLOT*

   Enter set up information appropriate to your data.



10. Plot a histogram of the data.

    [PLOT]



Angle Setting

You can ignore the angle measurement mode *unless* your Fit definition (in Symbolic view) involves a trigonometric function. In this case, you should specify in the mode screen whether the trigonometric units are to be interpreted in degrees, radians, or grads.

Save data

The data that you enter is automatically saved. When you are finished entering data values, you can press a key for another Statistics view (like [SYMB]), or you can switch to another aplet or HOME.

Edit a data set

In the Numeric view of the Statistics aplet, highlight the data value to change. Type a new value and press [ENTER], or press **EDIT** to copy the value to the edit line for modification. Press [ENTER] after modifying the value on the edit line.

Delete data

- To delete a single data item, highlight it and press [DEL]. The values below the deleted cell will scroll up one row.
- To delete a column of data, highlight an entry in that column and press [SHIFT] *CLEAR*. Select the column name.
- To delete all columns of data, press [SHIFT] *CLEAR*. Select `All columns`.

Insert data

Highlight the entry *following* the point of insertion. Press INS, then enter a number. It will write over the zero that was inserted.

Sort data values

1. In Numeric view, highlight the column you want to sort, and press SORT.
2. Select the `SORT ORDER` option. You can choose either `Ascending` or `Descending`.
3. Specify the `INDEPENDENT` and `DEPENDENT` data columns. Sorting is by the *independent* column. For instance, if Age is C1 and Income is C2 and you want to sort by Income, then you make C2 the independent column for the sorting and C1 the dependent column.
   – To sort just one column, choose `None` for the dependent column.
   – For one-variable statistics with two data columns, specify the frequency column as the dependent column.
4. Press OK.

Defining a regression model (2VAR)

The Symbolic view includes an expression (Fit1 through Fit5) that defines the regression model, or "fit", to use for the regression analysis of each two-variable data set.

There are three ways to select a regression model:

- Accept the default option to fit the data to a straight line.
- Select one of the available fit options in Symbolic Setup view.
- Enter your own mathematical expression in Symbolic view. This expression will be plotted, *but it will not be fitted to the data points.*

To choose the fit

1. In Numeric view, make sure 2VAR is set.
2. Press SHIFT *SETUP-SYMB* to display the Symbolic Setup view. Highlight the Fit number (`S1FIT` to `S5FIT`) you want to define.
3. Press CHOOS and select from the following list. Press OK when done. The regression formula for the fit is displayed in Symbolic view.

Fit models

Eight fit models are available:

Fit model	Meaning
`Linear`	(Default.) Fits the data to a straight line, $y = mx+b$. Uses a least-squares fit.
`Logarithmic`	Fits to a logarithmic curve, $y = m \ln x + b$.
`Exponential`	Fits to an exponential curve, $y = be^{mx}$.
`Power`	Fits to a power curve, $y = bx^m$.
`Quadratic`	Fits to a quadratic curve, $y = ax^2+bx+c$. Needs at least three points.
`Cubic`	Fits to a cubic curve, $y = ax^3+bx^2+cx+d$. Needs at least four points.
`Logistic`	Fits to a logistic curve, $y = \frac{L}{1 + ae^{(-bx)}}$, where L is the saturation value for growth. You can store a positive real value in L, or—if L=0—let L be computed automatically.
`User Defined`	Define your own expression (in Symbolic view.)

To define your own fit

1. In Numeric view, make sure 2VAR is set.
2. Display the Symbolic view.
3. Highlight the Fit expression (`Fit1`, etc.) for the desired data set.
4. Type in an expression and press ENTER.

   The independent variable must be X, and the expression must not contain any unknown variables.
   Example: $1.5 \times \cos x + 0.3 \times \sin x$.

This automatically changes the Fit type (`S1FIT`, etc.) in the Symbolic Setup view to `User Defined`.

Computed statistics

One-variable

Statistic	Definition
NΣ	Number of data points.
TOTΣ	Sum of data values (with their frequencies).
MEANΣ	Mean value of data set.
PVARΣ	Population variance of data set.
SVARΣ	Sample variance of data set.
PSDEV	Population standard deviation of data set.
SSDEV	Sample standard deviation of data set.
MINΣ	Minimum data value in data set.
Q1	First quartile: median of ordinals to left of median.
MEDIAN	Median value of data set.
Q3	Third quartile: median of ordinals to right of median.
MAXΣ	Maximum data value in data set.

When the data set contains an odd number of values, the data set's median value is not used when calculating Q1 and Q3 in the table above. For example, for the following data set:

{3,5,7,8,15,16,17}

only the first three items, 3, 5, and 7 are used to calculate Q1, and only the last three terms, 15, 16, and 17 are used to calculate Q3.

Two-variable

Statistic	Definition
MEANX	Mean of *x*- (independent) values.
ΣX	Sum of *x*-values.
ΣX2	Sum of x^2-values.
MEANY	Mean of *y*- (dependent) values.
ΣY	Sum of *y*-values.
ΣY2	Sum of y^2-values.
ΣXY	Sum of each *xy*.
SCOV	Sample covariance of independent and dependent data columns.
PCOV	Population covariance of independent and dependent data columns
CORR	Correlation coefficient of the independent and dependent data columns *for a linear fit only* (regardless of the Fit chosen). Returns a value from 0 to 1, where 1 is the best fit.
RELERR	The relative error (for the selected fit). Provides a measure of accuracy for the fit.

Plotting

You can plot:

- histograms (1VAR)
- box-and-whisker plots (1VAR)
- scatter plots of data (2VAR).

Once you have entered your data (NUM), defined your data set (SYMB), and defined your Fit model for two-variable statistics (SHIFT *SETUP-SYMB*), you can plot your data. You can select up to five scatter or box-and-whisker plots at a time. You can plot only one histogram at a time.

To plot statistical data

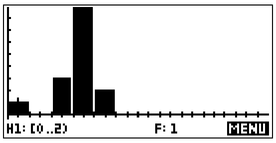
1. In Symbolic view (SYMB), select (✓CHK) the data sets you want to plot.
2. For one-variable data (1VAR), select the plot type in Plot Setup (SHIFT *SETUP-PLOT*). Highlight `STATPLOT`, press CHOOS, select either `Histogram` or `BoxWhisker`, and press OK.
3. For any plot, but especially for a histogram, adjust the plotting scale and range in the Plot Setup view. If you find histogram bars too fat or too thin, you can adjust them with the `HWIDTH` setting.
4. Press PLOT. If you have not adjusted the Plot Setup yourself, you can try VIEWS *select* `Auto Scale` OK.

HINT Auto Scale can be relied upon to give a good starting scale which can then be adjusted in the Plot Setup view.

Plot types

Histogram

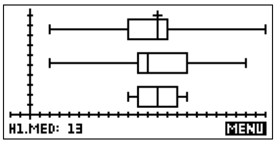
One-variable statistics. The numbers below the plot mean that the current bar (where the cursor is) starts at 0 and ends at 2 (not including 2), and the frequency for this column,



(that is, the number of data elements that fall between 0 and 2) is 1. You can see information about the next bar by pressing the ▶ key.

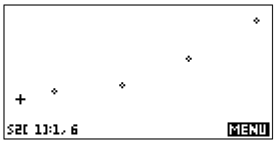
Box and Whisker Plot

One-variable statistics. The left whisker marks the minimum data value. The box marks the first quartile, the median, and the third quartile. The right whisker marks the maximum data value.

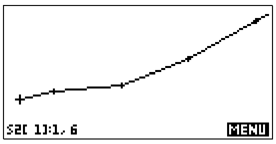


Scatter Plot

Two-variable statistics. The numbers below the plot indicate that the cursor is at the first data point for S2, at (1, 6). Press ▶ to move to the next data point and display information about it.



To connect the data points as they are plotted, checkmark `CONNECT` in the second page of the Plot Setup. *This is not a regression curve.*

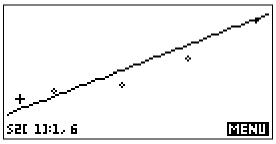


Fitting a curve to 2VAR data

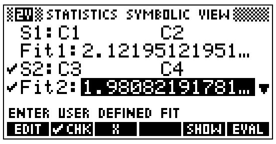
In the Plot view, press FIT. This draws a curve to fit the checked two-variable data set(s). See “To choose the fit” on page 8-11.

PLOT

MENU
FIT

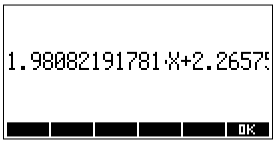


SYMB



SHOW

The expression in `Fit2` shows that the slope=1.98082191781 and the *y*-intercept=2.2657.



Correlation coefficient

The correlation coefficient is stored in the `CORR` variable. It is a measure of fit to a *linear* curve only. Regardless of the Fit model you have chosen, `CORR` relates to the linear model.

Relative Error

The *relative error* is stored in a variable named `RELERR`. The relative error provides a measure of fit accuracy for all fits, and it *does* depend on the Fit model you have chosen.

The relative error is a measure of the error between predicted values and actual values based on the specified Fit. A smaller number means a better fit.

HINT In order to access these variables after you plot a set of statistics, you must press NUM to access the numeric view and then STATS to display the correlation values. The values are stored in the variables when you access the Symbolic view.

Setting up the plot (Plot setup view)

The Plot Setup view (SHIFT *SETUP-PLOT*) sets most of the same plotting parameters as it does for the other built-in aplets.
See "Setting up the plot (Plot view setup)" on page 2-5.
Settings unique to the Statistics aplet are as follows:

Plot type (1VAR)

`STATPLOT` enables you to specify either a histogram or a box-and-whisker plot for one-variable statistics (when 1VAR is set). Press CHOOS to change the highlighted setting

Histogram width

`HWIDTH` enables you to specify the width of a histogram bar. This determines how many bars will fit in the display, as well as how the data is distributed (how many values each bar represents).

Histogram range

`HRNG` enables you to specify the range of values for a set of histogram bars. The range runs from the left edge of the leftmost bar to the right edge of the rightmost bar. You can limit the range to exclude any values you suspect are outliers.

Plotting mark (2VAR)

`S1MARK` through `S5MARK` enables you to specify one of five symbols to use to plot each data set. Press CHOOS to change the highlighted setting.

Connected points (2VAR)

`CONNECT` (on the second page), when checkmarked, connects the data points as they are plotted. *The resulting line is not the regression curve.* The order of plotting is according to the ascending order of independent values. For instance, the data set (1,1), (3,9), (4,16), (2,4) would be plotted and traced in the order (1,1), (2,4), (3,9), (4,16).

Trouble-shooting a plot

If you have problems plotting, check that you have the following:

- The correct 1VAR or 2VAR menu label on (Numeric view).
- The correct fit (regression model), if the data set is two-variable.
- Only the data sets to compute or plot are checkmarked (Symbolic view).
- The correct plotting range. Try using VIEWS `Auto Scale` (instead of PLOT), *or* adjust the plotting parameters (in Plot Setup) for the ranges of the axes and the width of histogram bars (`HWIDTH`).
- In 2VAR mode, ensure that both paired columns contain data, and that they are the same length.
- In 1VAR mode, ensure that a paired column of frequency values is the same length as the data column that it refers to.

Exploring the graph

The Plot view has menu keys for zooming, tracing, and coordinate display. There are also scaling options under VIEWS. These options are described in“Exploring the graph” on page 2-7.

Statistics aplet’s PLOT view keys

Key	Meaning
SHIFT *CLEAR*	Erases the plot.
VIEWS	Offers additional pre-defined views for splitting the screen, overlaying plots, and autoscaling the axes.
SHIFT ◄ SHIFT ►	Moves cursor to far left or far right.
ZOOM	Displays ZOOM menu.
TRACE	Turns trace mode on/off. The white box appears next to the option when Trace mode is active.
FIT	Turns fit mode on/off. Turning FIT on draws a curve to fit the data points according to the current regression model.
GOTO (2var statistics only)	Enables you to specify a value on the line of best fit to jump to or a data point number to jump to.
DEFN	Displays the equation of the regression curve.
MENU	Hides and displays the menu key labels. When the labels are hidden, any menu key displays the (x,y) coordinates. Pressing MENU redisplays the menu labels.

Calculating predicted values

The functions PREDX and PREDY estimate (predict) values for *X* or *Y* given a hypothetical value for the other. The estimation is made based on the curve that has been calculated to fit the data according to the specified fit.

Find predicted values

1. In Plot view, draw the regression curve for the data set.
2. Press ▼ to move to the regression curve.
3. Press GOTO and enter the value of *X*. The cursor jumps to the desired point on curve and the coordinate display shows *X* and the predicted value of *Y.*

   In HOME,

   – Enter PREDX(*y-value*) ENTER
   to find the predicted (estimated) value for the independent variable given a hypothetical dependent value.

   – Enter PREDY(*x-value*) to find the predicted value of the dependent variable given a hypothetical independent variable.

   You can type PREDX and PREDY into the edit line, or you can copy these function names from the MATH menu under the Stat-Two category.

HINT In cases where more than one fit curve is displayed, the PREDY function uses the most recently calculated curve. In order to avoid errors with this function, uncheck all fits except the one that you want to work with, or use the Plot View method.

9

Inference aplet

About the Inference aplet

The Inference capabilities 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

Example data

When you first access an input form for an Inference 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 on–line help provides a description of what the example data represents.

Getting started with the Inference aplet

This example describes the Inference aplet's options and functionality by stepping you through an example using the example data for the Z–Test on 1 mean.

Open the Inference aplet

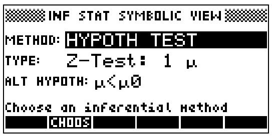
1. Open the Inference aplet.

   APLET

   Select `Inferential`

   START.

   The Inference aplet opens in the Symbolic view.



Inference aplet's SYMB view keys

The table below summarizes the options available in Symbolic view.

Hypothesis Tests	**Confidence Intervals**
Z: 1 μ, the Z–Test on 1 mean	Z–Int: 1 μ, the confidence interval for 1 mean, based on the Normal distribution
Z: $\mu_1 - \mu_2$, the Z–Test on the difference of two means	Z–Int: $\mu_1 - \mu_2$, the confidence interval for the difference of two means, based on the Normal distribution
Z: 1 P, the Z–Test on 1 proportion	Z–Int: 1 P, the confidence interval for 1 proportion, based on the Normal distribution
Z: $P_1 - P_2$, the Z–Test on the difference in two proportions	Z–Int: $P_1 - P_2$, the confidence interval for the difference of two proportions, based on the Normal distribution
T: 1 μ, the T–Test on 1 mean	T–Int: 1 μ, the confidence interval for 1 mean, based on the Student's t–distribution
T: $\mu_1 – \mu_2$, the T–Test on the difference of two means	T–Int: $\mu_1 - \mu_2$, the confidence interval for the difference of two means, based on the Student's t–distribution

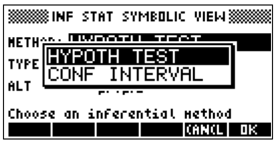
If you choose one of the hypothesis tests, you can choose the alternative hypothesis to test against the null hypothesis. For each test, there are three possible choices for an alternative hypothesis based on a quantitative comparison of two quantities. The null hypothesis is always that the two quantities are equal.Thus, the alternative hypotheses cover the various cases for the two quantities being unequal: <, >, and ≠.

In this section, we will use the example data for the Z–Test on 1 mean to illustrate how the aplet works and what features the various views present.

Define the inferential method

1. Select the `Hypothesis Test` inferential method.

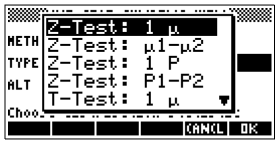
   CHOOS
   Select `HYPOTH TEST`



2. Define the type of test.

   OK ▼

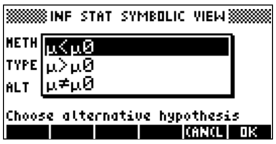
   CHOOS
   `Z–Test: 1 μ`



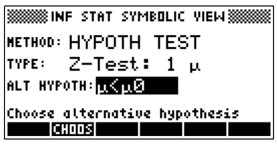
3. Select an alternative hypothesis.

   OK ▼

   CHOOS
   μ< μ 0



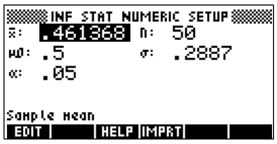
   OK



Enter data

4. Enter the sample statistics and population parameters that define the chosen test or interval.

   SHIFT *SETUP-NUM*



The table below lists the fields in this view for our current `Z–Test`: 1 μ example.

Field name	Definition
μ0	Assumed population mean
σ	Population standard deviation
$\bar{x}$	Sample mean
n	Sample size
α	Alpha level for the test

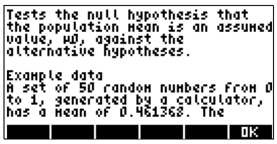
By default, each field already contains a value. These values constitute the example database and are explained in the HELP feature of this aplet.

Display on-line help

5. Display the on-line help.

   HELP

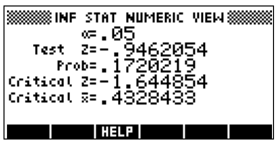
6. To close the on-line help, press OK.



Display test results in numeric format

7. Display the test results in numeric format.

   NUM



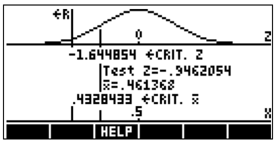
The test distribution value and its associated probability are displayed, along with the critical value(s) of the test and the associated critical value(s) of the statistic.

Note: You can access the on-line help in Numeric view.

Plot test results

8. Display a graphic view of the test results.

   PLOT

   Horizontal axes are presented for both the distribution variable and the test statistic. A generic bell curve represents the probability distribution function. Vertical lines mark the critical value(s) of the test, as well as the value of the test statistic. The rejection region is marked <R and the test numeric results are displayed between the horizontal axes.

Importing Sample Statistics from the Statistics aplet

The Inference aplet supports the calculation of confidence intervals and the testing of hypotheses based on data in the Statistics aplet. Computed statistics for a sample of data in a column in any Statistics-based aplet can be imported for use in the Inference aplet. The following example illustrates the process.

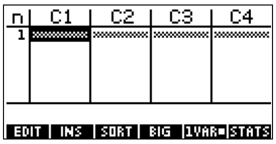
A calculator produces the following 6 random numbers:

0.529, 0.295, 0.952, 0.259, 0.925, and 0.592

Open the Statistics aplet

1. Open Statistics aplet. *Note: Reset current settings.*

   APLET *Select*
   `Statistics`
   RESET YES
   START

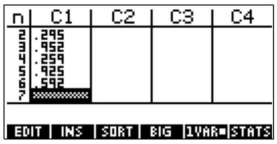
   

   The Statistics aplet opens in the Numeric view.

Enter data

2. In the C1 column, enter the random numbers produced by the calculator.

   [.]529 [ENTER]
   [.]295 [ENTER]
   [.]952 [ENTER]
   [.]259 [ENTER]
   [.]925 [ENTER]
   [.]592 [ENTER]



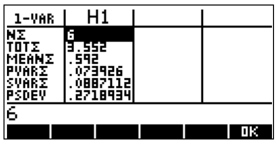
HINT If the Decimal Mark setting in the Modes input form ([SHIFT] *MODES*) is set to Comma, use [,] instead of [.].

3. If necessary, select 1–variable statistics. Do this by pressing the fifth menu key until **1VAR■** is displayed as its menu label.

Calculate statistics

4. Calculate statistics.

   STATS



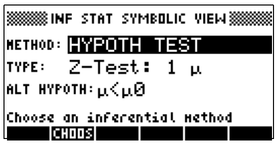
   The mean of 0.592 seems a little large compared to the expected value of 0.5. To see if the difference is statistically significant, we will use the statistics computed here to construct a confidence interval for the true mean of the population of random numbers and see whether or not this interval contains 0.5.

5. Press **OK** to close the computed statistics window.

Open Inference aplet

6. Open the Inference aplet and clear current settings.

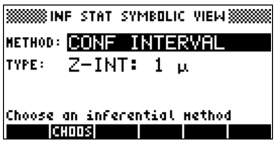
   [APLET] *Select* `Inference`
   RESET **YES**
   START



Choose inference method and type

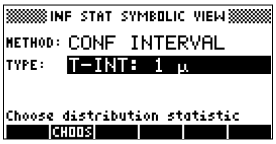
7. Choose an inference method.

   CHOOS
   Select `CONF INTERVAL`
   OK



8. Choose a distribution statistic type.

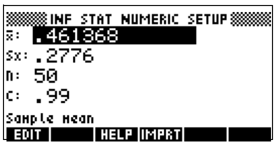
   ▼ CHOOS
   Select `T-Int: 1 μ`
   OK



Set up the interval calculation

9. Set up the interval calculation. *Note: The default values are sample data from the on-line help example.*

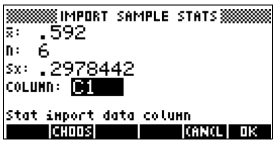
   SHIFT *SETUP-NUM*



Import the data

10. Import the data from the Statistics aplet. *Note: The data from C1 is displayed by default.*

    IMPRT



    Note: If there are other columns of data in the Statistics aplet, you could select a column and press OK *to see the statistics before importing them into the Numeric Setup view. Also, if there is more than one aplet based on the Statistics aplet, you are prompted to choose one.*

    OK

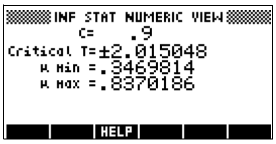
11. Specify a 90% confidence interval in the `C:` field.

[▼] [▼] [▼] *to move to the* `C:` *field*
0.9 [ENTER]

Display Numeric view

12. Display the confidence interval in the Numeric view. *Note: The interval setting is 0.5.*

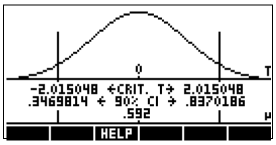
[NUM]



Display Plot view

13. Display the confidence interval in the Plot view.

[PLOT]



You can see, from the second text row, that the mean is contained within the 90% confidence interval (CI) of 0.3469814 to 0.8370186.

Note: The graph is a simple, generic bell-curve. It is not meant to accurately represent the t-distribution with 5 degrees of freedom.

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 of samples of the populations.

The HP 39G/40G hypothesis tests use the Normal Z–distribution or Student's t-distribution to calculate probabilities.

One–Sample Z–Test

Menu name

Z–Test: 1 μ

On the basis of statistics from a single sample, the 1 mean Z–Test 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 H_0: $\mu - \mu_0$.

You select one of the following alternative hypotheses against which to test the null hypothesis:

$$H_1 : \mu < \mu_0$$

$$H_1 : \mu > \mu_0$$

$$H_1 : \mu \neq \mu_0$$

Inputs

The inputs are:

Field name	Definition
$\bar{x}$	Sample mean.
n	Sample size.
μ_0	Hypothetical population mean.
σ	Population standard deviation.
α	Significance level.

Results

The results are:

Result	Description
Test Z	Z–test statistic.
Prob	Probability associated with the Z–Test statistic.
Critical Z	Boundary values of Z associated with the α level that you supplied.
Critical $\bar{x}$	Boundary values of $\bar{x}$ required by the α value that you supplied.

Two–Sample Z–Test

Menu name

Z–Test: μ1–μ2

On the basis of two samples, each from a separate population, this test measures the strength of the evidence for a selected hypothesis against the null hypothesis. The null hypothesis is that the mean of the two populations are equal (H_0: $\mu_1 = \mu_2$).

You select one of the following alternative hypotheses against which to test the null hypothesis:

$$H_1 : \mu_1 < \mu_2$$
$$H_1 : \mu_1 > \mu_2$$
$$H_1 : \mu_1 \neq \mu_2$$

Inputs

The inputs are:

Field name	Definition
$\bar{x}1$	Sample 1 mean.
$\bar{x}2$	Sample 2 mean.
n1	Sample 1 size.
n2	Sample 2 size.
σ1	Population 1 standard deviation.
σ2	Population 2 standard deviation.
α	Significance level.

Results

The results are:

Result	Description
Test Z	Z–Test statistic
Prob	Probability associated with the Z–Test statistic.
Critical Z	Boundary value of Z associated with the α level that you supplied.

One–Proportion Z–Test

Menu name

Z–Test: 1P

On the basis of statistics from a single sample, this test 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 two populations is equal. $H_0 \pi = \pi_0$

You select one of the following alternative hypotheses against which to test the null hypothesis:

$$H_1 : \pi < \pi_0$$

$$H_1 : \pi > \pi_0$$

$$H_1 : \pi \neq \pi_0$$

Inputs

The inputs are:

Field name	Definition
x	Number of successes in the sample.
n	Sample size.
π_0	Population proportion of successes.
α	Significance level.

Results

The results are:

Result	Description
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 level you supplied.

Two–Proportion Z–Test

Menu name

Z–Test: P1–P2

On the basis of statistics from two samples, each from a different population, the 2 proportion Z–Test 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 two populations is equal.
(H_0: $\pi_1 = \pi_2$).

You select one of the following alternative hypotheses against which to test the null hypothesis:

$$H_1 : \pi_1 < \pi_2$$
$$H_1 : \pi_1 > \pi_2$$
$$H_1 : \pi_1 \neq \pi_2$$

Inputs

The inputs are:

Field name	Definition
X1	Sample 1 mean.
X2	Sample 2 mean.
n1	Sample 1 size.
n2	Sample 2 size.
α	Significance level.

Results

The results are:

Result	Description
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 values of Z associated with the α level that you supplied.

One–Sample T–Test

Menu name

T–Test: 1 μ

The One–sample T–Test is used when the population standard deviation is not known. On the basis of statistics from a single sample, this test 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:)

$$H_1 : \mu < \mu_0$$

$$H_1 : \mu > \mu_0$$

$$H_1 : \mu \neq \mu_0$$

Inputs

The inputs are:

Field name	Definition
$\bar{x}$	Sample mean.
Sx	Sample standard deviation.
n	Sample size.
μ0	Hypothetical population mean.
α	Significance level.

Results

The results are:

Result	Description
Test T	T–Test statistic.
Prob	Probability associated with the T–Test statistic.
Critical T	Boundary value of T associated with the α level that you supplied.
Critical $\bar{x}$	Boundary value of $\bar{x}$ required by the α value that you supplied.

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, this test measures the strength of the evidence for a selected hypothesis against the null hypothesis. The null hypothesis is that the two populations means are equal (H_0: $\mu_1 = \mu_2$).

You select one of the following alternative hypotheses against which to test the null hypothesis

$$H_1{:}\mu_1 < \mu_2$$
$$H_1{:}\mu_1 > \mu_2$$
$$H_1{:}\mu_1 \neq \mu_2$$

Inputs

The inputs are:

Field name	Definition
$\bar{x}1$	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.
α	Significance level.
_Pooled?	Check this option to pool samples based on their standard deviations.

Results

The results are:

Result	Description
Test T	T–Test statistic.
Prob	Probability associated with the T–Test statistic.
Critical T	Boundary values of T associated with the α level that you supplied.

Confidence intervals

The confidence interval calculations that the HP 39G/40G 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

The inputs are:

Field name	Definition
$\bar{x}$	Sample mean.
σ	Population standard deviation.
n	Sample size.
C	Confidence level.

Results

The results are:

Result	Description
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 between the means of two populations, $\mu_1 - \mu_2$, when the population standard deviations, σ_1 and σ_2, are known.

Inputs

The inputs are:

Field name	Definition
$\bar{x}1$	Sample 1 mean.
$\bar{x}2$	Sample 2 mean.
n1	Sample 1 size.
n2	Sample 2 size.
σ1	Population 1 standard deviation.
σ2	Population 2 standard deviation.
C	Confidence level.

Results

The results are:

Result	Description
Critical Z	Critical value for Z.
Δ μ Min	Lower bound for $\mu_1 - \mu_2$.
Δ μ 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

The inputs are:

Field name	Definition
x	Sample success count.
n	Sample size.
C	Confidence level.

Results

The results are:

Result	Description
Critical Z	Critical value for Z.
π Min	Lower bound for π.
π Max	Upper bound for π.

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 between the proportions of successes in two populations.

Inputs

The inputs are:

Field name	Definition
$\bar{x}1$	Sample 1 success count.
$\bar{x}2$	Sample 2 success count.
n1	Sample 1 size.
n2	Sample 2 size.
C	Confidence level.

Results

The results are:

Result	Description
Critical Z	Critical value for Z.
$\Delta\,\pi$ Min	Lower bound for the difference between the proportions of successes.
$\Delta\,\pi$ Max	Upper bound for the difference between the proportions of successes.

One–Sample T–Interval

Menu name

T–INT: 1 μ

This option uses the Student's t–distribution to calculate a confidence interval for μ, the true mean of a population, for the case in which the true population standard deviation, σ, is unknown.

Inputs

The inputs are:

Field name	Definition
$\bar{x}$	Sample mean.
S*x*	Sample standard deviation.
n	Sample size.
C	Confidence level.

Results

The results are:

Result	Description
Critical T	Critical value for T.
μ Min	Lower bound for μ.
μ Max	Upper bound for μ.

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 between the means of two populations, $\mu_1 - \mu_2$, when the population standard deviations, $\sigma_1$and σ_2, are unknown.

Inputs

The inputs are:

Field name	**Definition**
$\bar{x}$ 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

The results are:

Result	**Description**
Critical T	Critical value for T.
Δ μ Min	Lower bound for $\mu_1 - \mu_2$.
Δ μ Max	Upper bound for $\mu_1 - \mu_2$.

10

Using mathematical functions

Math functions

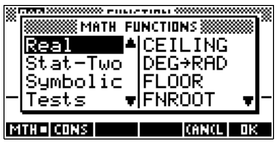
The HP 39G/40G contains many math functions. The functions are grouped in categories. For example, the Matrix category contains functions for manipulating matrices. The Probability category (shown as `Prob.` on the MATH menu) contains functions for working with probability.

To use a math function, you enter the function onto the command line, and include the arguments in parentheses after the function. You can also select a math function from the MATH menu.

The MATH menu

The MATH menu provides access to math functions and programming constants.

The MATH menu is organized by *category*. For each category of functions on the left, there is a list of function names on the right. The highlighted category is the current category.



- When you press MATH, you see the menu list of Math functions. The menu key MTH indicates that the MATH FUNCTIONS menu list is active.

To select a function

1. Press MATH to display the MATH menu. The categories appear in alphabetical order. Press ▼ or ▲ to scroll through the categories. To skip directly to a category, press the first letter of the category's name. *Note: You do not need to press* ALPHA *first*.
2. The list of functions (on the right) applies to the currently highlighted category (on the left). Use ► and ◄ to switch between the category list and the function list.
3. Highlight the name of the function you want and press OK. This copies the function name (and an initial parenthesis, if appropriate) to the edit line.

Function categories

- Calculus
- Complex numbers
- Constant
- Hyperbolic trig
- Lists
- Loop
- Matrices
- Polynomial
- Probability
- Real–numbers
- Stat–Two (Two–variable statistics)
- Symbolic
- Tests
- Trigonometry

Math functions by category

Following are definitions for all categories of functions except List, Matrix, and Statistics, each of which appears in its own chapter. Except for the keyboard operations, which do not appear in the MATH menu, all other functions are listed by their category in the MATH menu.

Syntax

Each function's definition includes its syntax, that is, the exact order and spelling of a function's name, its delimiters (punctuation), and its arguments. Note that the syntax for a function does not require spaces.

Functions common to keyboard and menus

These functions are common to the keyboard and menus.

SHIFT π	For a description, see "p" on page 10-9.
SHIFT *ARG*	For a description, see "ARG" on page 10-8.
d/dx	For a description, see "D" on page 10-7.
SHIFT *AND*	For a description, see "AND" on page 10-21.
SHIFT !	For a description, see "!" on page 10-13.
SHIFT Σ	For a description, see "S" on page 10-11.
SHIFT *EEX*	For a description, see "Scientific notation (powers of 10)" on page 1-19.
SHIFT ∫	For a description, see "S" on page 10-7.
SHIFT x^{-1}	The multiplicative inverse function finds the inverse of a square matrix, and the multiplicative inverse of a real or complex number. Also works on a list containing only these object types.

Keyboard functions

The most frequently used functions are available directly from the keyboard. Many of the keyboard functions also accept complex numbers as arguments.

[+], [-], [x], [/]

Add, Subtract, Multiply, Divide. Also accepts complex numbers, lists and matrices.

value1+ *value2*, etc.

[SHIFT] e^x

Natural exponential. Also accepts complex numbers.

`e^`*value*

Example

`e^5` returns `148.413159103`

[ln]

Natural logarithm. Also accepts complex numbers.

`LN`(*value*)

Example

`LN(1)` returns `0`

[SHIFT] 10^x

Exponential (antilogarithm). Also accepts complex numbers.

`10^`*value*

Example

`10^3` returns `1000`

[log]

Common logarithm. Also accepts complex numbers.

`LOG`(*value*)

Example

`LOG(100)` returns `2`

[SIN], [COS], [TAN]

Sine, cosine, tangent. Inputs and outputs depend on the current angle format (Degrees, Radians, or Grads).

`SIN`(*value*)
`COS`(*value*)
`TAN`(*value*)

Example

`TAN(45)` returns `1` (Degrees mode).

SHIFT *ASIN*

Arc sine: $\sin^{-1}x$. Output range is from –90° to 90°, –π/2 to π/2, or –100 to 100 grads. Inputs and outputs depend on the current angle format. Also accepts complex numbers.

ASIN(*value*)

Example

`ASIN(1)` returns `90` (Degrees mode).

SHIFT *ACOS*

Arc cosine: $\cos^{-1}x$. Output range is from 0° to 180°, 0 to π, or 0 to 200 grads. Inputs and outputs depend on the current angle format. Also accepts complex numbers. Output will be complex for values outside the normal COS domain of $-1 \le x \le 1$.

ACOS(*value*)

Example

`ACOS(1)` returns `0` (Degrees mode).

SHIFT *ATAN*

Arc tangent: $\tan^{-1}x$. Output range is from –90° to 90°, 2π/2 to π/2, or –100 to 100 grads. Inputs and outputs depend on the current angle format. Also accepts complex numbers.

ATAN(*value*)

Example

`ATAN(1)` returns `45` (Degrees mode).

x^2

Square. Also accepts complex numbers.

value^2

Example

18^2 returns `324`

SHIFT √

Square root. Also accepts complex numbers.

√*value*

Example

$\sqrt{324}$ returns `18`

(-)

Negation. Also accepts complex numbers.

–*value*

Example

`-(1,2)` returns `(-1,-2)`

[X^y]

Power (*x* raised to *y*). Also accepts complex numbers.

value^*power*

Example

`2^8` returns `256`

[SHIFT] *ABS*

Absolute value. For a complex number, this is $\sqrt{x^2 + y^2}$.

ABS(*value*)
ABS((*x*, *y*))

Example

`ABS(–1)` returns `1`
`ABS((1,2))` returns `2.2360679775`

[SHIFT] $\sqrt[n]{\ }$

Takes the *n*th root of *x*.

root `NTHROOT` *value*

Example

`3 NTHROOT 8` returns `2`

Calculus functions

The symbols for differentiation and integration are available directly form the keyboard—[d/dx] and ∫ respectively—as well as from the MATH menu.

∂

Differentiates *expression* with respect to the *variable* of differentiation. From the command line, use a formal name (S1, etc.) for a non-numeric result. See “Finding derivatives” on page 10-23.

∂*variable*(*expression*)

Example

`∂s1(s1`^{2}`+3*s1)` returns `2*s1+3`

∫

Integrates *expression* from *lower* to *upper* limits with respect to the *variable* of integration. To find the definite integral, both limits must have numeric values (that is, be numbers or real variables). To find the indefinite integral, one of the limits must be a formal variable (s1, etc.).

∫(*lower,upper,expression,variable*)

See “Using formal variables” on page 10-22 for further details.

Example

`∫(0,s1,2*X+3,X)` [ENTER] [▲] COPY [ENTER] finds the indefinite result `3*s1+2*(s1^2/2)`

See “To find the indefinite integral using formal variables” on page 10-25 for more information on finding indefinite integrals.

TAYLOR

Calculates the *n*th order Taylor polynomial of *expression* at the point where the given *variable* = 0.

`TAYLOR`(*expression,variable,n*)

Example

`TAYLOR(1 + sin(s1)`^{2}`,s1,5)` with Radians angle measure and Fraction number format (set in MODES) returns `1+s1^2-1/3*s1^4.`

Complex number functions

These functions are for complex numbers only. You can also use complex numbers with all trigonometric and hyperbolic functions, and with some real-number and keyboard functions. Enter complex numbers in the form (*x*,*y*), where *x* is the real part and *y* is the imaginary part.

ARG

Argument. Finds the angle defined by a complex number. Inputs and outputs use the current angle format set in Modes.

`ARG`((*x*,*y*))

Example

`ARG((3,3))` returns `45` (Degrees mode)

CONJ

Complex conjugate. Conjugation is the negation (sign reversal) of the imaginary part of a complex number.

`CONJ`((*x*,*y*))

Example

`CONJ((3,4))` returns `(3,-4)`

IM

Imaginary part, *y*, of a complex number, (*x*,*y*).

`IM` ((*x*,*y*))

Example

`IM((3,4))` returns `4`

RE

Real part *x*, of a complex number, (*x*,*y*).

`RE`((*x*,*y*))

Example

`RE((3,4))` returns `3`

Constants

The HP 39G/40G has an internal numeric representation for these constants.

e

Natural logarithm base. Internally represented as 2.71828182846.

e

i

Imaginary value for $\sqrt{-1}$, the complex number (0,1).

i

MAXREAL

Maximum real number. Internally represented as $9.99999999999 \times 10^{499}$.

MAXREAL

MINREAL

Minimum real number. Internally represented as 1×10^{-499}.

MINREAL

π

Internally represented as 3.14159265359.

π

Hyperbolic trigonometry

The hyperbolic trigonometry functions can also take complex numbers as arguments.

ACOSH

Inverse hyperbolic cosine : $\cosh^{-1}x$.

`ACOSH`(*value*)

ASINH

Inverse hyperbolic sine : $\sinh^{-1}x$.

`ASINH`(*value*)

ATANH

Inverse hyperbolic tangent : $\tanh^{-1}x$.

`ATANH`(*value*)

COSH

Hyperbolic cosine

`COSH`(*value*)

SINH

Hyperbolic sine.

`SINH`(*value*)

TANH

Hyperbolic tangent.

`TANH`(*value*)

ALOG

Antilogarithm (exponential). This is more accurate than `10^x` due to limitations of the power function.

`ALOG`(*value*)

EXP

Natural exponential. This is more accurate than e^x due to limitations of the power function.

`EXP`(*value*)

EXPM1

Exponent minus 1 : $e^x - 1$. This is more accurate than EXP when x is close to zero.

`EXPM1`(*value*)

LNP1

Natural log plus 1 : $\ln(x+1)$. This is more accurate than the natural logarithm function when x is close to zero.

`LNP1`(*value*)

List functions

These functions work on list data. See "List functions" on page 13-7.

Loop functions

The loop functions display a result after evaluating an expression a given number of times.

ITERATE

Repeatedly for *#times* evaluates an *expression* in terms of *variable*. The value for *variable* is updated each time, starting with *initialvalue.*

`ITERATE(`*expression*`,`*variable*`,`*initialvalue*`,` *#times*`)`

Example

`ITERATE(X`^{2}`,X,2,3)` returns `256`

RECURSE

Provides a method of defining a sequence without using the Symbolic view of the Sequence aplet. If used with | (“where”), RECURSE will step through the evaluation.

`RECURSE(`*sequencename*`,`*term-n*`,`*term1*`,`*term2*`)`

Example

`RECURSE(U,U(N-1)*N,1,2)` STO▶ `U1(N)`
Stores a factorial–calculating function named U1.

When you enter `U1(5)`, for example, the function calculates `5! (120)`.

Σ

Summation. Finds the sum of *expression* with respect to *variable* from *initialvalue* to *finalvalue.*

`Σ(`*variable*=*initialvalue*`,`*finalvalue*`,`*expression*`)`

Example

`Σ(C=1,5,C`^{2}`)` returns 55.

Matrix functions

These functions are for matrix data stored in matrix variables. See “Matrix functions and commands” on page 12-9.

Polynomial functions

Polynomials are products of constants (*coefficients*) and variables raised to powers (*terms*).

POLYCOEF

Polynomial coefficients. Returns the coefficients of the polynomial with the specified *roots*.

`POLYCOEF` ([*roots*])

Example

To find the polynomial with roots 2, –3, 4, –5:
`POLYCOEF([2,-3,4,-5])` returns `[1,2,-25,-26,120]`, representing $x^4+2x^3-25x^2-26x+120$.

POLYEVAL

Polynomial evaluation. Evaluates a polynomial with the specified *coefficients* for the *value* of *x*.

`POLYEVAL([`*coefficients*`],`*value*`)`

Example

For $x^4+2x^3-25x^2-26x+120$:
`POLYEVAL([1,2,-25,-26,120],8)` returns `3432`.

POLYFORM

Polynomial form. Creates a polynomial in *variable1* from *expression.*

`POLYFORM`(*expression,variable1*)

Example

`POLYFORM((X+1)^2+1,X)` returns `X^2+2*X+2`.

POLYROOT

Polynomial roots. Returns the roots for the *n*th-order polynomial with the specified *n*+1 *coefficients*.

`POLYROOT`([*coefficients*])

Example

For $x^4+2x^3-25x^2-26x+120$:
`POLYROOT([1,2,-25,-26,120])` returns `[2,-3,4,-5]`.

HINT The results of POLYROOT will often not be easily seen in HOME due to the number of decimal places, especially if they are complex numbers. It is better to store the results of POLYROOT to a matrix.

For example, `POLYROOT([1,0,0,-8]` STO▶ `M1` will store the three complex cube roots of 8 to matrix M1 as a complex vector. Then you can see them easily by going to the Matrix Catalog. and access them individually in calculations by referring to M1(1), M1(2) etc.

Probability functions

COMB

Number of combinations (without regard to order) of *n* things taken *r* at a time: $n!/(r!(n-r))$.

`COMB(`*n*`,`*r*`)`

Example

`COMB(5,2)` returns `10`. That is, there are ten different ways that five things can be combined two at a time.

!

Factorial of a positive integer. For non-integers, $! = \Gamma(x + 1)$. This calculates the gamma function.

value!

PERM

Number of permutations (with regard to order) of *n* things taken *r* at a time: $n!/(n\text{-}r)!$.

`PERM (`*n*`,`*r*`)`

Example

`PERM(5,2)` returns `20`. That is, there are 20 different permutations of five things taken two at a time.

RANDOM

Random number (between zero and 1). Produced by a pseudo-random number sequence. The algorithm used in the RANDOM function uses a “seed” number to begin its sequence. To ensure that two calculators must produce different results for the RANDOM function, use the RANDSEED function to seed different starting values before using RANDOM to produce the numbers.

`RANDOM`

HINT The setting of Time will be different for each calculator, so using RANDSEED(Time) is guaranteed to produce a set of numbers which are as close to random as possible. You can set the seed using the command RANDSEED.

UTPC

Upper-Tail Chi-Squared Probability given *degrees* of freedom, evaluated at *value*. Returns the probability that a χ^2 random variable is greater than *value*.

UTPC(*degrees*,*value*)

UTPF

Upper-Tail Snedecor's F Probability given *numerator* degrees of freedom and *denominator* degrees of freedom (of the F distribution), evaluated at *value*. Returns the probability that a Snedecor's F random variable is greater than *value.*

UTPF(*numerator*,*denominator*,*value*)

UTPN

Upper-Tail Normal Probability given *mean* and *variance*, evaluated at *value.* Returns the probability that a normal random variable is greater than *value* for a normal distribution. *Note: The variance is the square of the standard deviation*.

UTPN(*mean*,*variance*,*value*)

UTPT

Upper-Tail Student's t-Probability given *degrees* of freedom, evaluated at *value.* Returns the probability that the Student's t-random variable is greater than *value*.

UTPT(*degrees*,*value*)

Real-number functions

Some real-number functions can also take complex arguments.

CEILING

Smallest integer greater than or equal to *value*.

`CEILING`(*value*)

Examples

`CEILING(3.2)` returns `4`
`CEILING(-3.2)` returns `-3`

DEG→RAD

Degrees to radians. Converts *value* from Degrees angle format to Radians angle format.

`DEG→RAD`(*value*)

Example

`DEG→RAD(180)` returns `3.14159265359`, the value of π.

FLOOR

Greatest integer less than or equal to *value*.

`FLOOR`(*value*)

Example

`FLOOR(-3.2)` returns `-4`

FNROOT

Function root-finder (like the Solve aplet). Finds the value for the given *variable* at which *expression* most nearly evaluates to zero. Uses *guess* as initial estimate.

`FNROOT`(*expression, variable, guess*)

Example

`FNROOT(M*9.8/600-1,M,1)` returns `61.2244897959`.

FRAC

Fractional part.

`FRAC`(*value*)

Example

`FRAC (23.2)` returns `.2`

HMS→

Hours-minutes-seconds to decimal. Converts a number or expression in *H.MMSSs* format (time or angle that can include fractions of a second) to *x.x* format (number of hours or degrees with a decimal fraction).

`HMS→`(*H.MMSSs*)

Example

`HMS→(8.30)` returns `8.5`

→HMS

Decimal to hours-minutes-seconds. Converts a number or expression in *x.x* format (number of hours or degrees with a decimal fraction) to *H.MMSSs* format (time or angle up to fractions of a second).

`→HMS`(*x.x*)

Example

`→HMS(8.5)` returns `8.3`

INT

Integer part.

`INT`(*value*)

Example

`INT(23.2)` returns `23`

MANT

Mantissa (significant digits) of *value*.

`MANT`(*value*)

Example

`MANT(21.2E34)` returns `2.12`

MAX

Maximum. The greater of two values.

`MAX`(*value1*`,` *value2*)

Example

`MAX(210,25)` returns `210`

MIN

Minimum. The lesser of two values.

`MIN`(*value1*`,` *value2*)

Example

`MIN(210,25)` returns `25`

MOD

Modulo. The remainder of *value1*/*value2*.

value1 `MOD` *value2*

Example

`9 MOD 4` returns `1`

%

x percent of *y*; that is, *x*/`100*`*y*.

`%(`*x*`,`*y*`)`

Example

`%(20,50)` returns `10`

%CHANGE

Percent change from *x* to *y*, that is, 100(*y*–*x*)/*x*.

`%CHANGE(`*x*`,`*y*`)`

Example

`%CHANGE(20,50)` returns `150`

%TOTAL

Percent total : (100)*y/x*. What percentage of *x* is *y*.

`%TOTAL(`*x*`,`*y*`)`

Example

`%TOTAL(20,50)` returns `250`

RAD→DEG

Radians to degrees. Converts *value* from radians to degrees.

`RAD→DEG` (*value*)

Example

`RAD→DEG(π)` returns `180`

ROUND

Rounds *value* to decimal *places*. Accepts complex numbers.

`ROUND(`*value*`,` *places*`)`

Round can also round to a number of significant digits as showed in example 2.

Examples

`ROUND(7.8676,2)` returns `7.68`

`ROUND (0.0036757,-3)` returns `0.00368`

SIGN

Sign of *value*. If positive, the result is 1. If negative, –1. If zero, result is zero. For a complex number, this is the unit vector in the direction of the number.

`SIGN`(*value*)
`SIGN`((*x*,*y*))

Examples

`SIGN (–2) returns –1`

`SIGN((3,4))` returns `(.6,.8)`

TRUNCATE

Truncates *value* to decimal *places*. Accepts complex numbers.

`TRUNCATE`(*value*`,`*places*)

Example

`TRUNCATE(2.3678,2)` returns `2.36`

XPON

Exponent of *value*.

`XPON`(*value*)

Example

`XPON(123.4)` returns `2`

Statistics-Two

These are functions for use with two-variable statistics. See “Two-variable” on page 8-14.

Symbolic functions

The symbolic functions are used for symbolic manipulations of expressions. The variables can be formal or numeric, but the result is usually in symbolic form (not a number). You will find the symbols for the symbolic functions = and | (*where*) in the CHARS menu (SHIFT *CHARS*) as well as the MATH menu.

= (*equals*)

Sets an equality for an equation. This is *not* a logical operator and does *not* store values. (See “Test functions” on page 10-20.)

expression1=*expression2*

ISOLATE

Isolates the first occurrence of *variable* in *expression*=0 and returns a new expression, where *variable*=*newexpression.* The result is a general solution that represents multiple solutions by including the (formal) variables *s1* to represent any sign and *n1* to represent any integer.

`ISOLATE(`*expression*`,`*variable*`)`

Examples

`ISOLATE(2*X+8,X)` returns `-4`
`ISOLATE(A+B*X/C,X)` returns `-(A*C/B)`

LINEAR?

Tests whether *expression* is linear for the specified *variable*. Returns `0` (false) or `1` (true).

`LINEAR?(`*expression*`,`*variable*`)`

Example

`LINEAR?((X^2-1)/(X+1),X)` returns `0`

QUAD

Solves quadratic *expression*=0 for *variable* and returns a new expression, where *variable*=*newexpression.* The result is a general solution that represents both positive and negative solutions by including the formal variable *S1* to represent any sign: + or – .

`QUAD(`*expression*`,`*variable*`)`

Example

`QUAD((X-1)`^{2}`-7,X)` returns
`(2+s1*5.29150262213)/2`

QUOTE

Encloses an expression that should not be evaluated numerically.

`QUOTE(`*expression*)

Examples

`QUOTE(SIN(45))` STO▶ `F1(X)` stores the expression SIN(45) rather than the value of SIN(45).

Another method is to enclose the expression in single quotes.

For example, `X^3+2*X` STO▶ `F1(X)` puts the expression X^3_2*X into F1(X) in the Function aplet.

| (*where*)

Evaluates *expression* where each given variable is set to the given *value*. Defines numeric evaluation of a symbolic expression.

expression|(*variable1=value1, variable2=value2,...*)

Example

`3*(X+1)|(X=3)` returns `12`.

Test functions

The test functions are *logical* operators that always return either a 1 (*true*) or a 0 (*false*).

<

Less than. Returns 1 if true, 0 if false.

value1<value2

≤

Less than or equal to. Returns 1 if true, 0 if false.

value1≤value2

= =

Equals (logical test). Returns 1 if true, 0 if false.

value1==value2

≠

Not equal to. Returns 1 if true, 0 if false.

value1≠value2

>

Greater than. Returns 1 if true, 0 if false.

value1>value2

≥

Greater than or equal to. Returns 1 if true, 0 if false.

value1≥value2

AND Compares *value1* and *value2*. Returns 1 if they are both non-zero, otherwise returns 0.

value1 `AND` *value2*

IFTE If *expression* is true, do the *trueclause*; if not, do the *falseclause.*

`IFTE(`*expression*`,`*trueclause*`,`*falseclause*`)`

Example

IFTE(X>0,X^2,X^3)

NOT Returns 1 if *value* is zero, otherwise returns 0.

`NOT` *value*

OR Returns 1 if either *value1* or *value2* is non-zero, otherwise returns 0.

value1 `OR` *value2*

XOR Exclusive OR. Returns 1 if either *value1* or *value2*—but not both of them—is non-zero, otherwise returns 0.

value1 `XOR` *value2*

Trigonometry functions

The trigonometry functions can also take complex numbers as arguments. For SIN, COS, TAN, ASIN, ACOS, and ATAN, see the Keyboard category.

ACOT Arc cotangent.

`ACOT`(*value*)

ACSC Arc cosecant.

`ACSC`(*value*)

ASEC Arc secant.

`ASEC`(*value*)

COT Cotangent: cos*x*/sin*x*.

`COT`(*value*)

CSC Cosecant: 1/sin*x*

`CSC`(*value*)

SEC Secant: 1/cos*x*.

`SEC`(*value*)

Symbolic calculations

The HP 39G/40G has the ability to perform symbolic calculations, for example, symbolic integration and differentiation. You can perform symbolic calculations in HOME and in the Function aplet.

In HOME

When you perform calculations that contain normal variables, the calculator substitutes values for any variables. For example, if you enter A+B on the command line and press ENTER, the calculator retrieves the values for A and B from memory and substitutes them in the calculation.

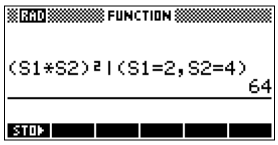
Using formal variables

To perform symbolic calculations, for example symbolic differentiations and integrations, you need to use formal names. The HP 39G/40G has six formal names available for use in symbolic calculations. These are S0 to S5. When you perform a calculation that contains a formal name, the HP 39G/40G does not carry out any substitutions.

You can mix formal names and real variables. Evaluating `(A+B+S1)`^{2} will evaluate `A+B`, but not `S1`.

If you need to evaluate an expression that contains formal names numerically, you use the | (*where*) command, listed in the Math menu under the Symbolic category.

For example to evaluate `(S1*S2)`^{2} when `S1=2` and `S2=4`, you would enter the calculation as follows:



(The | symbol is in the CHARS menu: press SHIFT *CHARS*. The = sign is listed in the MATH menu under Symbolic functions.)

Symbolic calculations in the Function aplet

You can perform symbolic operations in the Function aplet's Symbolic view. For example, to find the derivative of a function in the Function aplet's Symbolic view, you define two functions and define the second function as a derivative of the first function. You then evaluate the second function. See "To find derivatives in the Function aplet's Symbolic view" on page 10-24 for an example.

Finding derivatives

The HP 39G/40G can perform symbolic differentiation on some functions. There are two ways of using the HP 39G/40G to find derivatives.

- You can perform differentiations in HOME by using the formal variables, S1 to S5.
- You can perform differentiations of functions of X in the Function aplet.

To find derivatives in HOME

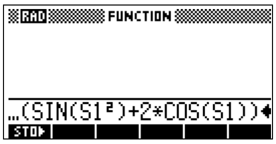
To find the derivative of the function in HOME, use a formal variable in place of X. If you use X, the differentiation function substitutes the value that X holds, and returns a numeric result.

For example, consider the function:

$$dx(\sin(x^2) + 2\cos(x))$$

1. Enter the differentiation function onto the command line, substituting S1 in place of X.

   d/dx ALPHA S1
   (SIN ALPHA S1
   x²) + 2 x
   COS ALPHA S1
))

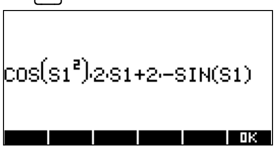


2. Evaluate the function.

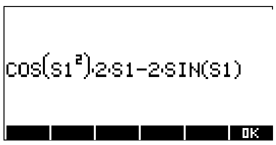
   ENTER

3. Show the result.

   ▲ SHOW



HP 39G



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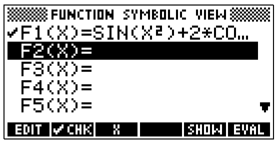
To find derivatives in the Function aplet's Symbolic view

To find the derivative of the function in the Function aplet's Symbolic view, you define two functions and define the second function as a derivative of the first function. For example, to differentiate $\sin(x^2) + 2\cos x$:

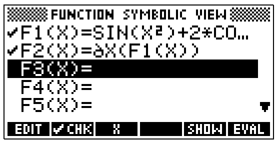
1. Access the Function aplet's Symbolic view and define F1.

   SYMB SIN x²)
   + 2 X
   COS) OK



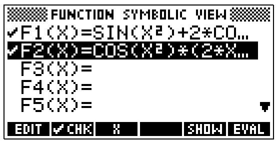
2. Define F2(X) as the derivative of F(1).

   d/dx (ALPHA
   F1 ( ))
   OK



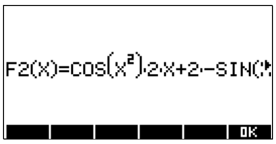
3. Select F2(X) and evaluate it.

   ▲ EVAL

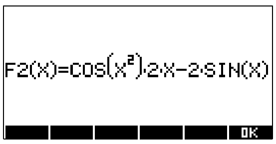


4. Press SHOW to display the result. (Use the arrow keys to view the entire function.)

   SHOW



HP 39G



HP 40G

You could also just define

$F1(x) = dx(\sin(x^2) + 2\cos(x))$.

To find the indefinite integral using formal variables

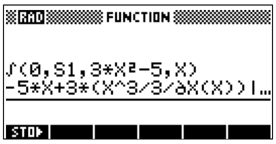
For example, to find the indefinite integral of

$\int 3x^2 - 5dx$ use:

$\int (0, S1, 3X^2 - 5, X)$

1. Enter the function.

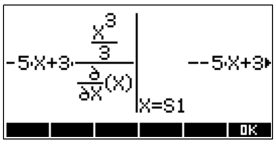
   [SHIFT] [d/dx] 0 [,]
   [ALPHA] S1 [,] 3 [x]
   [ALPHA] X [x²] [-] 5 [,]
   [ALPHA] X [)] [ENTER]



HINT If the Decimal Mark setting in the Modes input form ([SHIFT] *MODES*)is set to Comma, use [.] instead of [,].

2. Show the result format.

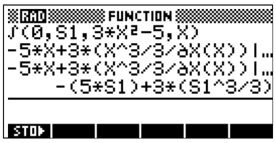
   [▲]
   SHOW



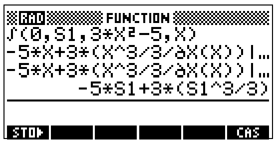
3. Press OK to close the show window.

4. Copy the result and evaluate.

   COPY [ENTER]



HP 39G



HP 40G

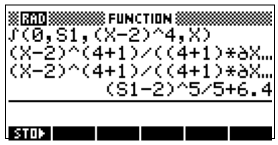
Thus, substituting X for S1, it can be seen that:

$$\int 3x^2 - 5dx = -5x + 3\left(\frac{\frac{x^3}{3}}{\frac{\partial}{\partial X}(X)}\right)$$

This result derives from substituting *X=S1* and *X=0* into the original expression found in step 1. However, substituting *X=0* will not always evaluate to zero and may result in an unwanted constant.

To see this, consider: $\int (x-2)^4 dx = \frac{(x-2)^5}{5}$

The 'extra' constant of 6.4 results from the substitution of $x = 0$ into $(x-2)^5/5$, and should be disregarded if an *indefinite* integral is required.



11

Variables and memory management

Introduction

The HP 39G/40G has approximately 232K of user memory. The calculator uses this memory to store variables, perform computation, and store history.

A variable is an object that you create in memory to hold data. The HP 39G/40G has two types of variables, home variables and aplet variables.

- Home variables are available in all aplets. For example, you can store real numbers in variables A to Z and complex numbers in variables Z0 to Z9. These can be numbers you have entered, or the results of calculations. These variables are available within all aplets and within any programs.
- Aplet variables apply only to a single aplet. Aplets have specific variables allocated to them which vary from aplet to aplet.

You use the calculator's memory to store the following objects:

- copies of aplets with specific configurations
- new aplets that you download
- aplet variables
- home variables
- variables created through a catalog or editor, for example a matrix or a text note
- programs that you create.

You can use the Memory Manager (SHIFT *MEMORY*) to view the amount of memory available. The catalog views, which are accessible via the Memory Manager, can be used to transfer variables such as lists or matrices between calculators.

Storing and recalling variables

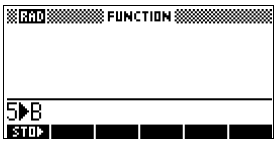
You can store numbers or expressions from a previous input or result into variables.

Numeric Precision

A number stored in a variable is always stored as a 12-digit mantissa with a 3-digit exponent. Numeric precision in the display, however, depends on the display mode (Standard, Fixed, Scientific, Engineering, or Fraction). A displayed number has only the precision that is displayed. If you copy it from the HOME view display history, you obtain only the precision displayed, not the full internal precision. On the other hand, the variable *Ans* always contains the most recent result to full precision.

To store a value

1. On the command line, enter the value or the calculation for the result you wish to store.
2. Press STO▶
3. Enter a name for the variable.
4. Press ENTER.

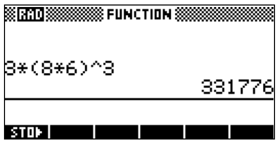


To store the results of a calculation

If the value you want to store is in the HOME view display history, for example the results of a previous calculation, you need to copy it to the command line, then store it.

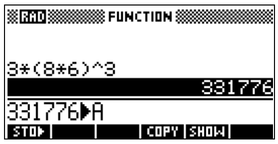
1. Perform the calculation for the result you want to store.

   3 [X] [(] 8 [x] 6 [)] [x^Y] 3
   [ENTER]



2. Move the highlight to the result you wish to store.
3. Press COPY to copy the result to the command line.
4. Press STO▶.
5. Enter a name for the variable.

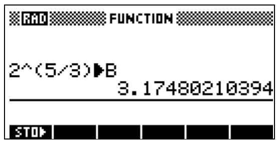
   [▲] COPY STO▶ [ALPHA]
   A



6. Press [ENTER] to store the result.

The results of a calculation can also be stored directly to a variable. For example:

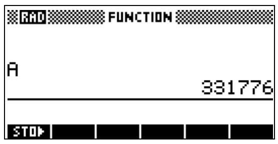
2 [x^Y] [(] 5 [÷] 3 [)]
STO▶ [ALPHA] B [ENTER]



To recall a value

To recall a variable's value, type the name of the variable and press [ENTER].

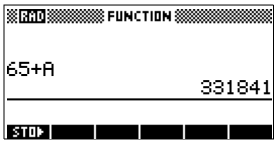
[ALPHA] A [ENTER]



To use variables in calculations

You can use variables in calculations. The calculator substitutes the variable's value in the calculation:

65 [+] [ALPHA] A [ENTER]



The VARS menu

You use the VARS menu to access all variables in the calculator. The VARS menu is organised by category. For each variable category in the left column, there is a list of variables in the right column. You select a variable category and then select a variable in the category.

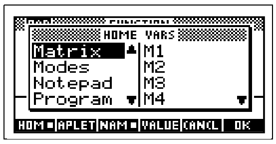
1. Open the VARS menu.

   [VARS]

2. Use the arrow keys or press the alpha key of the first letter in the category to select a variable category.

   For example, to select the Matrix category, press [)].

   Note: In this instance, there is no need to press the ALPHA key.

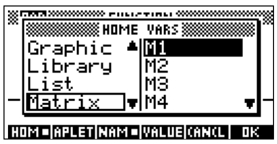


3. Move the highlight to the variables column.

   [▶]

4. Use the arrow keys to select the variable that you want. For example, to select the M2 variable, press [▼].

   [▼]



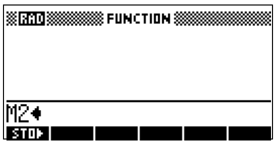
5. Choose whether to place the variable name or the variable value on the command line.

   – Press **VALUE** to indicate that you want the variable's contents to appear on the command line.

   – Press **NAME** to indicate that you want the variable's name to appear on the command line.

6. Press **OK** to place the value or name on the command line. The selected object appears on the command line.

   OK



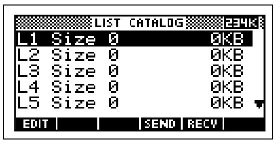
Note: The VARS menu can also be used to enter the names or values of variables into programs.

Example

This example demonstrates how to use the VARS menu to add the contents of two list variables, and to store the result in another list variable.

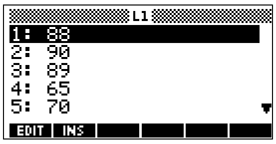
1. Display the List catalog.

   SHIFT *LIST*
   to select L1
   EDIT



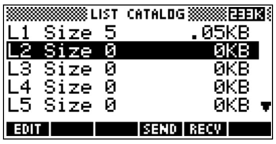
2. Enter the data for L1.

   88 **OK** 90 **OK** 89 **OK**
   65 **OK** 70 **OK**



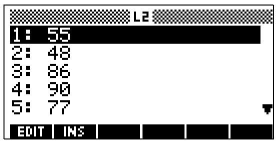
3. Return to the List Catalog to create L2.

   SHIFT *LIST*
   ▼ *to select L2*
   EDIT



4. Enter data for L2.

   55 OK 48 OK 86 OK
   90 OK 77 OK

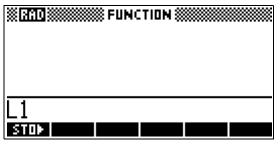


5. Press HOME to access HOME.
6. Open the variable menu and select L1.

   VARS ▼ ▼ ▼ ►

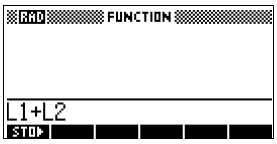
7. Copy it to the command line. *Note: Because the* NAME *option is highlighted, the variable's name, rather than its contents, is copied to the command line.*

   OK



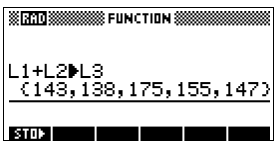
8. Insert the + operator and select the L2 variable from the List variables.

   + VARS
   ▼ ▼ ▼ ► ▼ OK



9. Store the answer in the List catalog L3 variable.

   STO▶ ALPHA L3 ENTER



   Note: You can also type list names directly from the keyboard.

Home variables

It is not possible to store data of one type in a variable of another type. For example, you use the Matrix catalog to create matrices. You can create up to ten matrices, and you can store these in variables M0 to M9. You cannot store matrices in variables other than M0 to M9.

Category	Available names
Complex	Z0 to Z9 For example, (1,2) STO▶ Z0 or 2+3*i* STO▶ Z1. You can enter a complex number by typing (*r*,*i*), where *r* represents the real part, and *i* represents the imaginary part.
Graphic	G0 to G9 See "Graphic commands" on page 15-20 for more information on storing graphic objects via programming commands. See "To store into a graphics variable" on page 14-5 for more information on storing graphic object via the sketch view.
Library	Aplet library variables can store aplets that you have created, either by saving a copy of a standard aplet, or downloading an aplet from another source.
List	L0 to L9 For example, {1,2,3} STO▶ L1.
Matrix	M0 to M9 can store matrices or vectors. For example, [[1,2],[3,4]] STO▶ M0.
Modes	Modes variables store the modes settings that you can configure using SHIFT *MODES*.
Notepad	Notepad variables store notes.
Program	Program variables store programs.
Real	A to Z and θ. For example, 7.45 STO▶ A.

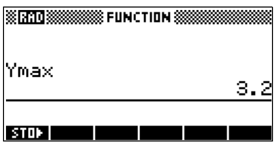
Aplet variables

Aplet variables store values that are unique to a particular aplet. These include symbolic expressions and equations (see below), settings for the Plot and Numeric views, and the results of some calculations such as roots and intersections. See the Reference Information chapter for more information about aplet variables.

Category	Available names
Function	F0 to F9 (Symbolic view). See “Function aplet variables” on page R-9.
Parametric	X0, Y0 to X9, Y9 (Symbolic view). See “Parametric aplet variables” on page R-10.
Polar	R0 to R9 (Symbolic view). See “Polar aplet variables” on page R-11.
Sequence	U0 to U9 (Symbolic view). See “Sequence aplet variables” on page R-12.
Solve	E0 to E9 (Symbolic view). See “Solve aplet variables” on page R-13.
Statistics	C0 to C9 (Numeric view). See “Statistics aplet variables” on page R-14.

To access an aplet variable

1. Open the aplet that contains the variable you want to recall.
2. Press VARS to display the VARS menu.
3. Use the arrow keys to select a variable category in the left column, then press ▶ to access the variables in the right column.
4. Use the arrow keys to select a variable in the right column.
5. To copy the name of the variable onto the edit line, press OK. (NAME is the default setting.)
6. To copy the value of the variable into the edit line, press VALUE and press OK.



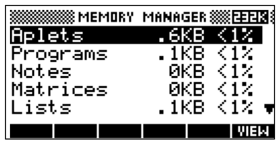
Memory Manager

You can use the Memory Manager to determine the amount of available memory on the calculator. You can also use Memory Manager to organize memory. For example, if the available memory is low, you can use the Memory Manager to determine which aplets or variables consume large amounts of memory. You can make deletions to free up memory.

Example

1. Start the Memory Manager. A list of variable categories is displayed.

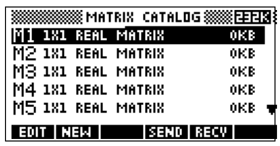
   SHIFT *MEMORY*

   Free memory is displayed in the top right corner and the body of the screen lists each category, the memory it uses, and the percentage of the total memory it uses.

2. Select the category with which you want to work and press **VIEW**. Memory Manager displays memory details of variables within the category.

   ▼ ▼ ▼ **VIEW**

3. To delete variables in a category:
   – Press DEL to delete the selected variable.
   – Press SHIFT *CLEAR* to delete all variables in the selected category.

12

Matrices

Introduction

You can perform matrix calculations in HOME and in programs. The matrix *and each row* of a matrix appear in brackets, and the elements and rows are separated by commas. For example, the following matrix:

$$\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \end{bmatrix}$$

is displayed in the history as:
[[1,2,3],[4,5,6]]

(If the Decimal Mark in MODES is set to Comma, then the row separators are periods.)

You can enter matrices directly in the command line, or create them in the matrix editor.

Vectors

Vectors are one-dimensional arrays. They are composed of just one row. A vector is represented with single brackets; for example, [1,2,3]. A vector can be a real number vector or a complex number vector, for example [(1,2), (7,3)].

Matrices

Matrices are two-dimensional arrays. They are composed of more than one row and more than one column. Two-dimensional matrices are represented with nested brackets; for example, [[1,2,3],[4,5,6]]. You can create complex matrices, for example, [[(1,2), (3,4)], [(4,5), (6,7)]].

Matrix Variables

There are ten matrix variables available, named M0 to M9. You can use them in calculations in HOME or in a program. You can retrieve the matrix names from the VARS menu, or just type their names from the keyboard.

Creating and storing matrices

You can create, edit, delete, send, and receive matrices in the Matrix catalog.

To open the Matrix catalog, press SHIFT *MATRIX*.

You can also create and store matrices—named or unnamed—-in HOME. For example, the command:

POLYROOT([1,0,–1,0])►M1

stores the root of the complex vector of length 3 into the M1 variable. M1 now contains the three roots of
$x^3 - x = 0$

Matrix Catalog keys

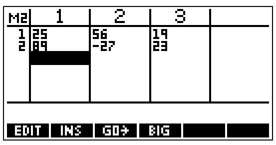
The table below lists the operations of the menu keys in the Matrix Catalog, as well as the use of Delete (DEL) and Clear (SHIFT *CLEAR*).

Key	Meaning
EDIT	Opens the highlighted matrix for editing.
NEW	Prompts for a matrix type, then opens an empty matrix with the highlighted name.
SEND	Transmits the highlighted matrix to another HP 39G/40G or a disk drive. See “Sending and receiving aplets” on page 16-5.
RECV	Receives a matrix from another HP 39G/40G or a disk drive. See “Sending and receiving aplets” on page 16-5.
DEL	Clears the highlighted matrix.
SHIFT *CLEAR*	Clears all matrices.
SHIFT ▼ or ▲	Moves to the end or the beginning of the catalog.

To create a matrix in the matrix catalog

1. Press [SHIFT] *MATRIX* to open the Matrix catalog. The Matrix catalog lists the 10 available matrix variables, M0 to M9.
2. Highlight the matrix variable name you want to use and press **NEW**.
3. Select the type of matrix to create.
   – **For a vector (one-dimensional array)**, select `Real vector` or `Complex vector`. Certain operations (+, -, `CROSS`) do not recognize a one-dimensional matrix as a vector, so this selection is important.
   – **For a matrix (two-dimensional array),** select `Real matrix` or `Complex matrix`.
4. For each element in the matrix, type a number or an expression, and press [ENTER]. (The expression may not contain symbolic variable names.)

   For complex numbers, enter each number in complex form; that is, (*a*, *b*), where *a* is the real part and *b* is the imaginary part. You must include the parentheses and the comma.
5. Use the cursor keys to move to a different row or column. You can change the direction of the highlight bar by pressing **GO**. The **GO** menu key toggles between the following three options:
   – **GO↓** specifies that the cursor moves to the cell below the current cell when you press [ENTER].
   – **GO→** specifies that the cursor moves to the cell to the right of the current cell when you press [ENTER].
   – **GO** specifies that the cursor stays in the current cell when you press [ENTER].
6. When done, press [SHIFT] *MATRIX* to see the Matrix catalog, or press [HOME] to return to HOME. The matrix entries are automatically stored.



A matrix is listed with two dimensions, even if it is 3×1. A vector is listed with the number of elements, such as 3.

To transmit a matrix

You can send matrices between calculators just as you can send aplets, programs, lists, and notes.

1. Align the HP 39G calculators' infrared ports.
2. Open the Matrix catalogs on both calculators.
3. Highlight the matrix to send.
4. Press SEND.
5. Press RECV on the receiving calculator.

Matrices can also be transmitted to or from a computer a cable and Connectivity Kit.

Working with matrices

To edit a matrix

In the Matrix catalog, highlight the name of the matrix you want to edit and press EDIT.

Matrix edit keys

The following table lists the matrix edit key operations.

Key	Meaning
EDIT	Copies the highlighted element to the edit line.
INS	Inserts a row of zeros above, or a column of zeros to the left, of the highlighted cell. (You are prompted to choose row or column.)
GO	A three-way toggle for cursor advancement in the Matrix editor. GO→ advances to the right, GO↓, advances downward, and GO does not advance at all.
BIG	Switches between larger and smaller font sizes.
DEL	Deletes the highlighted cells, row, or column (you are prompted to make a choice).
SHIFT *CLEAR*	Clears all elements from the matrix.
SHIFT ▲ ▼ ► ◄	Moves to the first row, last row, first column, or last column respectively.

To display a matrix

- In the Matrix catalog (SHIFT *MATRIX*), highlight the matrix name and press **EDIT**.
- In HOME, enter the name of the matrix variable and press ENTER.

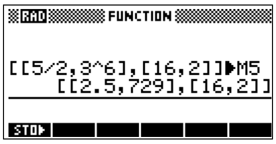
To display one element

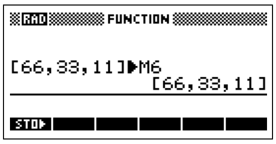
In HOME, enter *matrixname*(*row*,*column*). For example, if M2 is [[3,4],[5,6]], then M2(1,2) ENTER returns 4.

To create a matrix in HOME

1. Enter the matrix in the edit line. Start and end the matrix *and each row* with square brackets (the shifted 5 and 6 keys).
2. Separate each element *and each row* with a comma. Example: [[1,2],[3,4]].
3. Press ENTER to enter and display the matrix.

The left screen below shows the matrix [[2.5,729],[16,2]] being stored into M5. The screen on the right shows the vector [66,33,11] being stored into M6. Note that you can enter an expression (like 5/2) for an element of the matrix, and it will be evaluated.

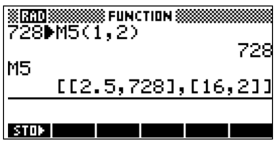




To store one element

In HOME, enter:
value **STO▶** *matrixname*(*row*,*column*)
For example, to change the element in the first row and second column of M5 to 728, then display the resulting matrix:

728 **STO▶**
ALPHA M5 (1 , 2)
ENTER ALPHA M5
ENTER.



An attempt to store an element to a row or column beyond the size of the matrix results in an error message.

Matrix arithmetic

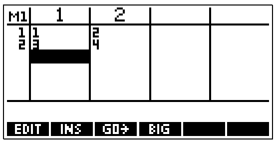
You can use the arithmetic functions (+, –, ×, /) with matrix arguments. Division left–multiplies by the inverse of the divisor. You can enter the matrices themselves or enter the names of stored matrix variables. The matrices can be real or complex.

For the next four examples, store [[1,2],[3,4]] into M1 and [[5,6],[7,8]] into M2.

Example

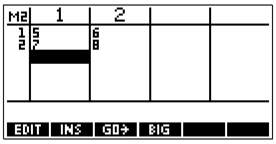
1. Create the first matrix.

   SHIFT *MATRIX* NEW OK
   1 ENTER 2 ENTER ▼
   3 ENTER 4 ENTER



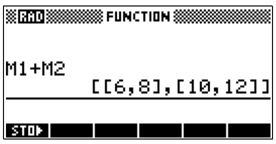
2. Create the second matrix.

   SHIFT *MATRIX* ▼ NEW
   OK 5 ENTER 6 ENTER
   ▼ 7 ENTER 8 ENTER



3. Add the matrices that you created.

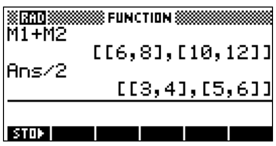
   HOME ALPHA M1 +
   ALPHA M2 ENTER



To multiply and divide by a scalar

For division by a scalar, enter the matrix first, then the operator, then the scalar. For multiplication, the order of the operands does not matter. The matrix and the scalar can be real or complex. For example, to divide the result of the previous example by 2, use the following key presses:

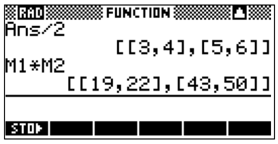
÷ 2 ENTER



To multiply two matrices

To multiply the two matrices M1 and M2 that you created for the previous example, use the following keystrokes:

ALPHA M1 x ALPHA M2
ENTER



To multiply a matrix by a vector, enter the matrix first, then the vector. The number of elements in the vector must equal the number of columns in the matrix.

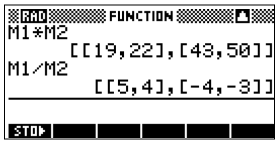
To divide by a square matrix

For division of a matrix or a vector by a square matrix, the number of rows of the dividend (or the number of elements, if it is a vector) must equal the number of rows in the divisor.

This operation is not a mathematical division: it is a left–multiplication by the inverse of the divisor. M1/M2 is equivalent to $M2^{-1}$ * M1.

To divide the two matrices M1 and M2 that you created for the previous example, use the following keystrokes:

ALPHA M1 ÷ ALPHA M2
ENTER



To invert a matrix

You can invert a *square matrix* in HOME by typing the matrix (or its variable name) and pressing SHIFT x^{-1} ENTER. Or you can use the matrix INVERSE command. Enter INVERSE(*matrixname*) in HOME and press ENTER.

To negate each element

You can change the sign of each element in a matrix by pressing (-) before the matrix name.

Solving systems of linear equations

Example

Solve the following linear system:

$$\begin{aligned} 2x + 3y + 4z &= 5 \\ x + y - z &= 7 \\ 4x - y + 2z &= 1 \end{aligned}$$

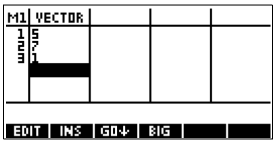
1. Open the Matrix catalog and choose to create a vector in the M1 variable.

   SHIFT *MATRIX* **NEW**

   ▼ ENTER

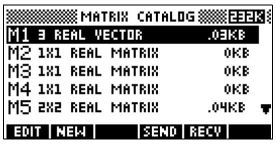
2. Create the vector of the constants in the linear system.

   5 ENTER 7 ENTER
   1 ENTER



3. Return to the Matrix catalog. The vector you created is listed as M1.

   SHIFT *MATRIX*



4. Select the M2 variable and create a new matrix.

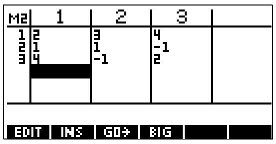
   ▼ **NEW**

   Select `Real matrix`

   OK

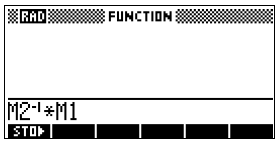
5. Create a new matrix and enter the equation coefficients.

   2 ENTER 3 ENTER
   4 ENTER ▼
   1 ENTER 1 ENTER
   (-) 1 ENTER 4 ENTER
   (-) 1 ENTER 2 ENTER



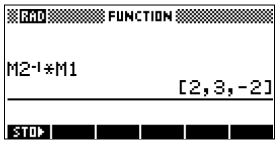
6. Return to HOME and enter the calculation to left multiply the constants vector by the inverse of the coefficients matrix.

   HOME ALPHA M2
   SHIFT x^{-1} x
   ALPHA M1



7. Evaluate the calculation.

   ENTER



The result is a vector of the solutions:

- $x = 2$
- $y = 3$
- $z = -2$

An alternative method, is to use the RREF function. See “RREF” on page 12-12.

Matrix functions and commands

About functions

- Functions can be used in any aplet or in HOME. They are listed in the MATH menu under the Matrix category. They can be used in mathematical expressions—primarily in HOME—as well as in programs.
- Functions always produce and display a result. They do not change any stored variables, such as a matrix variable.
- Functions have arguments that are enclosed in parentheses and separated by commas; for example, CROSS(*vector1*,*vector2*). The matrix input can be either a matrix variable name (such as M1) or the actual matrix data inside brackets. For example, CROSS(M1,[1,2]).

About commands

Matrix commands are listed in the CMDS menu (SHIFT *CMDS*), in the matrix category.

See "Matrix commands" on page 15-23 for details of the matrix commands available for use in programming.

Functions differ from commands in that a function can be used in an expression. Commands cannot be used in an expression.

Argument conventions

- For *row#* or *column#*, supply the number of the row (counting from the top, starting with 1) or the number of the column (counting from the left, starting with 1).
- The argument *matrix* can refer to either a vector or a matrix.

Matrix functions

COLNORM

Column Norm. Finds the maximum value (over all columns) of the sums of the absolute values of all elements in a column.

COLNORM(*matrix*)

COND

Condition Number. Finds the 1-norm (column norm) of a square *matrix*.

COND(*matrix*)

CROSS

Cross Product of *vector1* with *vector2*.

CROSS(*vector1*, *vector2*)

DET

Determinant of a square *matrix*.

DET(*matrix*)

DOT

Dot Product of two arrays, *matrix1 matrix2*.

DOT(*matrix1*, *matrix2*)

EIGENVAL

Displays the eigenvalues in vector form for *matrix*.

EIGENVAL(*matrix*)

EIGENVV

Eigenvectors and Eigenvalues for a square *matrix*. Displays a list of two arrays. The first contains the eigenvectors and the second contains the eigenvalues.

EIGENVV(*matrix*)

IDENMAT

Identity matrix. Creates a square matrix of dimension *size* × *size* whose diagonal elements are 1 and off-diagonal elements are zero.

IDENMAT(*size*)

INVERSE

Inverts a square matrix (real or complex).

INVERSE(*matrix*)

LQ

LQ Factorization. Factors an *m* × *n matrix* into three matrices: {[[*m* × *n lowertrapezoidal*]],[[*n* × *n orthogonal*]], [[*m* × *m permutation*]]}.

LQ(*matrix*)

LSQ

Least Squares. Displays the minimum norm least squares *matrix* (or *vector*).

LSQ(*matrix1*, *matrix2*)

LU

LU Decomposition. Factors a square *matrix* into three matrices: {[[*lowertriangular*]],[[*uppertriangular*]],[[*permutation*]]} The *uppertriangular* has ones on its diagonal.

LU(*matrix*)

MAKEMAT

Make Matrix. Creates a matrix of dimension *rows* × *columns*, using *expression* to calculate each element. If *expression* contains the variables I and J, then the calculation for each element substitutes the current row number for I and the current column number for J.

MAKEMAT(*expression*, *rows*, *columns*)

Example

MAKEMAT(0,3,3) returns a 3×3 zero matrix, [[0,0,0],[0,0,0],[0,0,0]].

QR QR Factorization. Factors an $m \times n$ *matrix* into three matrices: {[[$m \times m$ *orthogonal*]],[[$m \times n$ *uppertrapezoidal*]],[[$n \times n$ *permutation*]]}.

QR(*matrix*)

RANK Rank of a rectangular *matrix.*

RANK(*matrix*)

ROWNORM Row Norm. Finds the maximum value (over all rows) for the sums of the absolute values of all elements in a row.

ROWNORM(*matrix*)

RREF Reduced Row Echelon Form. Changes a rectangular *matrix* to its reduced row-echelon form.

RREF(*matrix*)

SCHUR Schur Decomposition. Factors a square *matrix* into two matrices. If *matrix* is real, then the result is {[[*orthogonal*]],[[*upper-quasi triangular*]]}.
If *matrix* is complex, then the result is {[[*unitary*]],[[*upper-triangular*]]}.

SCHUR(*matrix*)

SIZE Dimensions of *matrix.* Returned as a list: {rows,columns}.

SIZE(*matrix*)

SPECNORM Spectral Norm of *matrix*.

SPECNORM(*matrix*)

SPECRAD Spectral Radius of a square *matrix*.

SPECRAD(*matrix*)

SVD Singular Value Decomposition. Factors an $m \times n$ *matrix* into two matrices and a vector:
{[[$m \times m$ *square orthogonal*]],[[$n \times n$ *square orthogonal*]], [*real*]}.

SVD(*matrix*)

SVL Singular Values. Returns a vector containing the singular values of *matrix.*

SVL(*matrix*)

TRACE

Finds the trace of a square *matrix*. The trace is equal to the sum of the diagonal elements. (It is also equal to the sum of the eigenvalues.)

TRACE(*matrix*)

TRN

Transposes *matrix*. For a complex matrix, TRN finds the conjugate transpose.

TRN(*matrix*)

Examples

Identity Matrix

You can create an identity matrix with the IDENMAT function. For example, IDENMAT(2) creates the 2×2 identity matrix [[1,0],[0,1]].

You can also create an identity matrix using the MAKEMAT (*make matrix*) function. For example, entering MAKEMAT(I≠J,4,4) creates a 4 × 4 matrix showing the numeral 1 for all elements except zeros on the diagonal. The logical operator ≠ returns 0 when I (the row number) and J (the column number) are equal, and returns 1 when they are not equal.

Transposing a Matrix

The TRN function swaps the row-column and column-row elements of a matrix. For instance, element 1,2 (row 1, column 2) is swapped with element 2,1; element 2,3 is swapped with element 3,2; and so on.

For example, TRN([[1,2],[3,4]]) creates the matrix [[1,3],[2,4]].

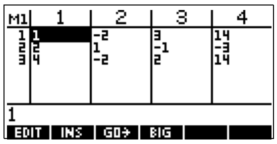
Reduced-Row Echelon Form

The following set of equations

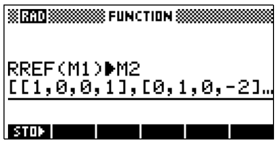
$$x - 2y + 3z = 14$$
$$2x + y - z = -3$$
$$4x - 2y + 2z = 14$$

can be written as the augmented matrix $\left[\begin{array}{ccc|c} 1 & -2 & 3 & 14 \\ 2 & 1 & -1 & -3 \\ 4 & -2 & 2 & 14 \end{array}\right]$

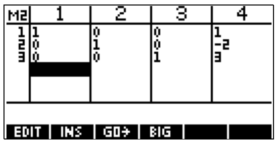
which can then stored as a 3×4 real matrix in M1.



You can use the RREF function to change this to reduced row echelon form, storing it as M2 for convenience.



The reduced row echelon matrix gives the solution to the linear equation in the forth column.

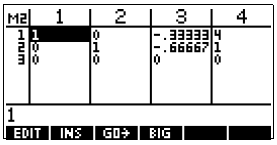


An advantage of using the RREF function is that it will also work with inconsistent matrices resulting from systems of equations which have no solution or infinite solutions.

For example, the following set of equations has an infinite number of solutions:

$$x + y - z = 5$$
$$2x - y = 7$$
$$x - 2y + z = 2$$

The final row of zeros in the reduced–row echelon form of the augmented matrix indicates an inconsistency.



13

Lists

You can do list operations in HOME and in programs. A list consists of comma-separated real or complex numbers, expressions, or matrices, all enclosed in braces. A list may, for example, contain a sequence of real numbers such as `{1,2,3}`. (If the Decimal Mark in MODES is set to Comma, then the separators are periods.) Lists represent a convenient way to group related objects.

There are ten list variables available, named L0 to L9. You can use them in calculations or expressions in HOME or in a program. Retrieve the list names from the VARS menu, or just type their names from the keyboard.

You can create, edit, delete, send, and receive named lists in the List catalog (SHIFT *LIST*). You can also create and store lists—named or unnnamed—in HOME.

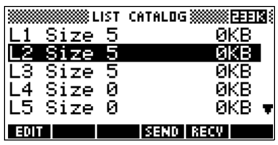
Creating lists

List variables are identical in behaviour to the columns C1.C0 in the Statistics aplet. You can store a statistics column to a list (or vice versa) and use any of the list functions on the statistics columns, or the statistics functions, on the list variables.

Create a list in the List Catalog

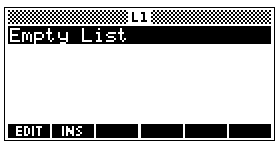
1. Open the List catalog.

   SHIFT *LIST*.



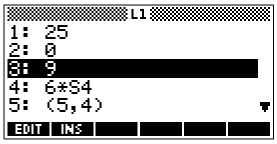
2. Highlight the list name you want to use (L1, etc.) and press EDIT to display the List editor.

   EDIT



3. Enter the values you want in the list, pressing [ENTER] after each one.

   Values can be real or complex numbers (or an expression). If you enter a calculation, it is evaluated and the result is inserted in the list.

4. When done, press [SHIFT] *LIST* to see the List catalog, or press [HOME] to return to HOME.

List catalog keys

The list catalog keys are:

Key	Meaning
EDIT	Opens the highlighted list for editing.
SEND	Transmits the highlighted list to another HP 39G/40G or a PC. See “Sending and receiving aplets” on page 16-5 for further information.
RECV	Receives a list from another HP 39G/40G or a PC. See “Sending and receiving aplets” on page 16-5 for further information.
[DEL]	Clears the highlighted list.
[SHIFT] *CLEAR*	Clears all lists.
[SHIFT] [▼] or [▲]	Moves to the end or the beginning of the catalog.

List edit keys

When you press edit to create or change a list, the following keys are available to you:

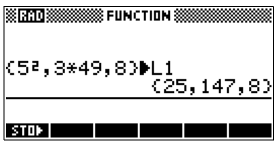
Key	Meaning
EDIT	Copies the highlighted list item into the edit line.
INS	Inserts a new value before the highlighted item.
DEL	Deletes the highlighted item from the list.
SHIFT *CLEAR*	Clears all elements from the list.
SHIFT ▼ or ▲	Moves to the end or the beginning of the list.

Create a list in HOME

1. Enter the list in the edit line. Start and end the list with braces (the shifted 8 and 9 keys) and separate each element with a comma.
2. Press ENTER to evaluate and display the list.

   Immediately after typing in the list, you can store it in a variable by pressing STO▶ *listname* ENTER. The list variable names are L0 through L9.

   This example stores the list {25,147,8} in L1. (You can omit the final brace when entering a list.)



Displaying and editing lists

To display a list

- In the List catalog, highlight the list name and press EDIT.
- In HOME, enter the name of the list and press ENTER.

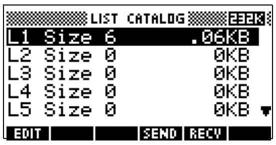
To display one element

In HOME, enter *listname*(*element#*). For example, if L2 is {3,4,5,6}, then `L2(2)` ENTER returns `4`.

To edit a list

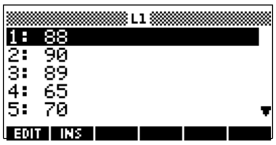
1. Open the List catalog.

   SHIFT *LIST*.



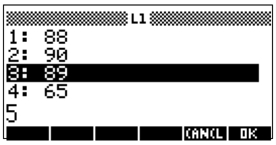
2. Press ▲ or ▼ to highlight the name of the list you want to edit (L1, etc.) and press EDIT to display the list contents.

   EDIT

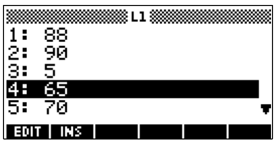


3. Press ▲ or ▼ to highlight the element you want to edit. In this example, edit the third element so that it has a value of 5.

   ▼ ▼ EDIT
   DEL DEL
   5



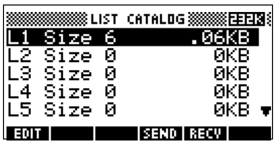
4. Press OK.



To insert an element in a list

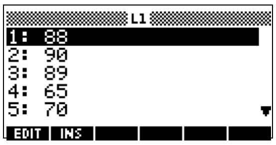
1. Open the List catalog.

   SHIFT *LIST*.



2. Press ▲ or ▼ to highlight the name of the list you want to edit (L1, etc.) and press **EDIT** to display the list contents.

   EDIT



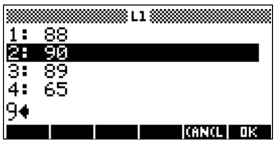
3. Press ▲ or ▼ to the insertion position.

   New elements are inserted above the highlighted position. In this example, an element, with the value of 9, is inserted between the first and second elements in the list.

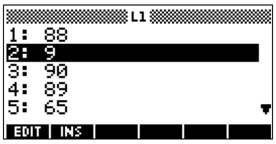
   ▼

   INS

   9



4. Press **OK**.



To store one element

In HOME, enter *value* **STO▸** *listname*(*element*). For example, to store the second element of L1 to 148, type
`148` **STO▸** `L1(2)` ENTER.

Deleting lists

To delete a list

In the List catalog, highlight the list name and press [DEL]. You are prompted if you want to delete the contents of the highlighted list variable. Press [ENTER] to delete the contents.

To delete all lists

In the List catalog, press [SHIFT] *CLEAR*.

Transmitting lists

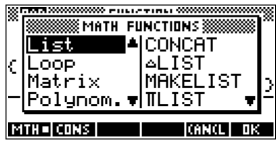
You can send lists to calculators or PCs just as you can aplets, programs, matrices, and notes.

1. Align the HP 39G calculators' infrared ports.
2. Open the List catalogs on both calculators.
3. Highlight the list to send.
4. Press SEND.
5. Press RECV on the receiving calculator.

Lists can also be transmitted to or from a computer a cable and Connectivity Kit.

List functions

Following are details of list functions. You can use them in HOME, as well as in programs.



You can type in the name of the function, or you can copy the name of the function from the List category of the MATH menu. Press MATH ((the alpha L character key). This displays the List category. Press ▶, select a function, and press OK.

List functions have the following syntax:

- Functions have *arguments* that are enclosed in parentheses and separated by commas. Example: `CONCAT(L1,L2)`. An argument can be either a list variable name (such as L1) *or* the actual list. For example, `REVERSE({1,2,3})`.
- If Decimal Mark in MODES is set to Comma, use periods to separate arguments. For example, `CONCAT(L1.L2)`.

Common operators like +, –, ×, and / can take lists as arguments. If there are two arguments and both are lists, then the lists must have the same length, since the calculation pairs up the elements. If there are two arguments and one is a real number, then the calculation pairs the number with each element of the list.

Example

`5*{1,2,3}` returns `{5,10,15}`.

Besides the common operators that can take numbers, matrices, or lists as arguments, there are commands that can only operate on lists.

CONCAT

Concatenates two lists into a new list.

`CONCAT(`*list1*`,`*list2*`)`

Example

`CONCAT({1,2,3},{4})` returns `{1,2,3,4}`.

ΔLIST

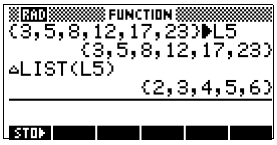
Creates a new list composed of the differences between the sequential elements in *list1*. The new list has one fewer elements than *list1*. The first differences for $\{x_1\ x_2\ ...\ x_n\}$ are $\{x_2 – x_1\ ...\ x_n – x_{n–1}\}$.

`ΔLIST(`*list1*`)`

Example

In HOME, store {3,5,8,12,17,23} in L5 and find the first differences for the list.

HOME SHIFT {3,5,8,12,
17,23 SHIFT } STO▶
ALPHA L 5 ENTER
MATH L ▶
Select `ΔLIST` OK
ALPHA L5 ENTER



MAKELIST

Calculates a sequence of elements for a new list. Evaluates *expression* with *variable* from *begin* to *end* values, taken at *increment* steps.

`MAKELIST(`*expression*`,`*variable*`,`*begin*`,`*end*`,` *increment*`)`

The MAKELIST function generates a series by automatically producing a list from the repeated evaluation of an expression.

Example

In HOME, generate a list of squares from 23 to 27.

MATH L ▶ *Select*
`MAKELIST` OK
ALPHA A x^2
, ALPHA A , 23 , 27
, 1)
ENTER

HINT If the Decimal Mark setting in the Modes input form (SHIFT *MODES*)is set to Comma, use . instead of ,.

ΠLIST

Calculates the product of all elements in list.

`ΠLIST(`*list*`)`

Example

`ΠLIST({2,3,4})` returns `24`.

POS

Returns the position of an element within a list. The *element* can be a value, a variable, or an expression. If there is more than one instance of the element, the position of the first occurrence is returned. A value of 0 is returned if there is no occurrence of the specified element.

`POS(`*list, element*`)`

Example

`POS ({3, 7, 12, 19},12)` returns `3`

REVERSE

Creates a list by reversing the order of the elements in a list.

`REVERSE(`*list*`)`

SIZE

Calculates the number of elements in a list.

`SIZE(`*list*`)`

Also works with matrices.

ΣLIST

Calculates the sum of all elements in list.

`ΣLIST(`*list*`)`

Example

`ΣLIST({2,3,4})` returns `9`.

SORT

Sorts elements in ascending order.

`SORT(`*list*`)`

Finding statistical values for list elements

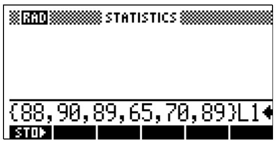
To find values such as the mean, median, maximum, and minimum values of the elements in a list, use the Statistics aplet.

Example

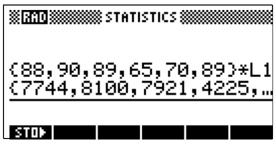
In this example, use the Statistics aplet to find the mean, median, maximum and minimum values of the elements in the list, L1.

1. Create L1 with values 88, 90, 89, 65, 70, and 89.

   SHIFT { 88 , 90 , 89 , 65 , 70 , 89 SHIFT } STO▸ ALPHA L1



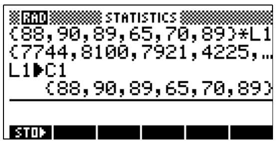
   ENTER



HINT If the Decimal Mark setting in the Modes input form (SHIFT *MODES*)is set to Comma, use . instead of ,.

2. In HOME, store L1 into C1. You will then be able to see the list data in the Numeric view of the Statistics aplet.

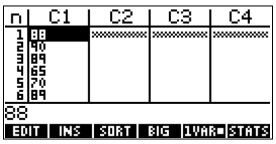
   ALPHA L1 STO▸ ALPHA C1 ENTER



3. Start the Statistics aplet, and select 1–variable mode (press 2VAR, if necessary, to display 1VAR).

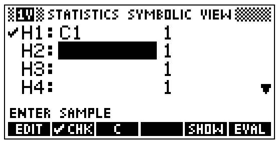
   APLET *Select* `Statistics` START

   Note: Your list values are now in column1 (C1).



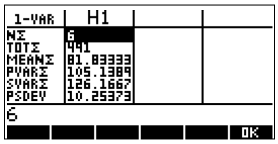
4. In the Symbolic view, define H1 (for example) as C1 (sample) and 1 (frequency). Make sure that H1 is checkmarked.

SYMB



5. Go to the Numeric view to display calculated statistics.

NUM STATS



See “One-variable” on page 8-13 for the meaning of each computed statistic.

14

Notes and sketches

Introduction

The HP 39G/40G has text and picture editors for entering *notes* and *sketches*.

- *Each aplet* has its own independent **Note view** and **Sketch view**. Notes and sketches that you create in these views are associated with the aplet. When you save the aplet, or send it to another calculator, the notes and sketches are saved or sent as well.
- The **Notepad** is a collection of notes independent of all aplets. These notes can also be sent to another calculator via the Notepad Catalog.

Aplet note view

You can attach text to an aplet in its Note view.

To write a note in Note view

1. In an aplet, press SHIFT *NOTE* for the Note view.
2. Use the note editing keys shown in the table in the following section.
3. Set Alpha lock (A...Z) for quick entry of letters. For *lowercase* Alpha lock, press SHIFT A...Z.
4. While Alpha lock is on:
   - To type a single letter of the opposite case, press SHIFT *letter.*
   - To type a single non-alpha character (such as 5 or [ ), press ALPHA first. (This turns off Alpha lock for one character.)

   Your work is automatically saved. Press any view key (NUM, SYMB, PLOT, VIEWS) or HOME to exit the Notes view.

Note edit keys

Key	Meaning
SPACE	Space key for text entry.
PAGE▼	Displays next page of a multi-page note.
A...Z	Alpha-lock for letter entry.
SHIFT A...Z	Lower-case Alpha-lock.
BKSP	Backspaces cursor and deletes character.
DEL	Deletes current character.
ENTER	Starts a new line.
SHIFT *CLEAR*	Erases the entire note.
VARS	Menu for entering variable names, and contents of variables.
MATH	Menu for entering math operations, and constants.
SHIFT *CMDS*	Menu for entering program commands.
SHIFT *CHARS*	Displays special characters. To type one, highlight it and press OK. To copy a character *without* closing the CHARS screen, press ECHO.

Aplet sketch view

You can attach pictures to an aplet in its Sketch view (SHIFT *SKETCH*). Your work is automatically saved with the aplet. Press any other view key or HOME to exit the Sketch view

Sketch keys

Key	Meaning
STO▶	Stores the specified portion of the current sketch to a graphics variable (G1 through G0).
NEWP	Adds a new, blank page to the current sketch set.
PAGE▼	Displays next sketch in the sketch set. Animates if held down.
TEXT	Opens the edit line to type a text label.
DRAW	Displays the menu-key labels for drawing.
DEL	Deletes the current sketch.
SHIFT *CLEAR*	Erases the entire sketch set.
−	Toggles menu key labels on and off. If menu key labels are hidden, − or any menu key, redisplays the menu key labels.

To draw a line

1. In an aplet, press SHIFT *SKETCH* for the Sketch view.
2. In Sketch view, press **DRAW** and move the cursor to where you want to start the line
3. Press **LINE**. This turns on line-drawing.
4. Move the cursor in any direction to the end point of the line by pressing the ▲, ▼, ►, ◄ keys.
5. Press **OK** to finish the line.

To draw a box

1. In Sketch view, press **DRAW** and move the cursor to where you want any corner of the box to be.
2. Press **BOX**. This turns on box-drawing.
3. Move the cursor to mark the opposite corner for the box. You can adjust the size of the box by moving the cursor.
4. Press **OK** to finish the box.

To draw a circle

1. In Sketch view, press **DRAW** and move the cursor to where you want the center of the circle to be.
2. Press **CIRCL**. This turns on circle drawing.
3. Move the cursor the distance of the radius.
4. Press **OK** to draw the circle.

DRAW keys

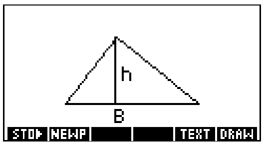
Key	Meaning
DOT+	Dot on. Turns pixels on as the cursor moves.
DOT-	Dot off. Turns pixels off as the cursor moves.
LINE	Draws a line from the cursor's starting position to the cursor's current position. Press **OK** when you have finished. You can draw a line at any angle by moving the cursor.
BOX	Draws a box from the cursor's starting position to the point at which you press **OK**.
CIRCL	Draws a circle with the cursor's starting position as the center. The radius is the distance between the cursor's starting and ending position. Press **OK** to draw the circle.

To label parts of a sketch

1. Press **TEXT** and type the text in the edit line. To lock the Alpha shift on, press **A...Z** (for uppercase) or SHIFT **A...Z** (for lowercase).

   To make the label a smaller character size, turn off **BIG■** before pressing **A...Z**. (**BIG** is a toggle between small and large font size). The smaller character size cannot display lowercase letters.

2. Press **OK**.
3. Position the label where you want it by pressing the ▲, ▼, ►, ◄ keys.
4. Press **OK** again to affix the label.
5. Press **DRAW** to continue drawing, or press HOME to exit Sketch view.



To create a set of sketches

You can create a set of up to ten sketches. This allows for simple animation.

- After making a sketch, press **NEWP** to add a new, blank page. You can now make a new sketch, which becomes part of the current set of sketches.
- To view the next sketch in an existing set, press **PAGE▼**. Hold **PAGE▼** down for animation.
- To remove the current page in the current sketch series, press DEL.

To store into a graphics variable

You can define a portion of a sketch inside a box, and then store that graphic into a graphics variable.

1. In the Sketch view, display the sketch you want to copy (store into a variable).
2. Press **STO▶**.
3. Highlight the variable name you want to use and press **OK**.
4. Draw a box around the portion you want to copy: move the cursor to one corner, press **OK**, then move the cursor to the opposite corner and press **OK**.

To import a graphics variable

You can copy the contents of a graphics variable into the Sketch view of an aplet.

1. Open the Sketch view of the aplet (SHIFT *SKETCH*). The graphic will be copied here.
2. Press VARS, **HOME**. Highlight `Graphic`, then press ▶ and highlight the name of the variable (`G1`, etc.).
3. Press **VALUE** **OK** to recall the contents of the graphics variable.
4. Move the box to where you would like to copy the graphic, then press **OK**.

The notepad

Subject to available memory, you can store as many notes as you want in the Notepad (SHIFT *NOTEPAD*). These notes are independent of any aplet. The Notepad catalog lists the existing entries by name. *It does not include notes that were created in aplets' Note views, but these can be imported. See "To import a note" on page 14-8.*

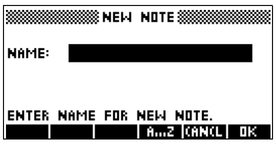
To create a note in the Notepad

1. .Display the Notepad catalog.

   SHIFT *NOTEPAD*

2. Create a new note.

   NEW



3. Enter a name for your note.

   A...Z
   MYNOTE
   OK

   Note: In this example, the name of the note is 'MYNOTE'.

4. Write your note.

   See “Note edit keys” on page 14-2 for more information on the entry and editing of notes.

5. When you are finished, press HOME or an aplet key to exit Notepad. *Your work is automatically saved.*

Notepad Catalog keys

Key	Meaning
EDIT	Opens the selected note for editing.
NEW	Begins a new note, and asks for a name.
SEND	Transmits the selected note to another HP 39G/40G or PC.
RECV	Receives a note being transmitted from another HP 39G/40G or PC.
DEL	Deletes the selected note.
SHIFT *CLEAR*	Deletes all notes in the catalog.

To import a note

You can import a note from the Notepad into an aplet's Note view, and vice-versa. Suppose you want to copy a note named "Assignments" from the Notepad into the Function Note view:

1. In the Function aplet, display the Note view (SHIFT *NOTE*).
2. Press VARS HOME, highlight `Notepad` in the left-hand list, then highlight the name "Assignments" in the right-hand list.
3. Press VALUE OK to copy the *contents* of "Assignments" to the Function Note view.

   Note: To recall the name instead of the contents, press NAME *instead of* VALUE.

Suppose you want to copy the Note view from the current aplet into the note "Assignments" in the Notepad.

1. In the Notepad (SHIFT *NOTEPAD*), open the note "Assignments".
2. Press VARS APLET, highlight `Note` in the left column, then press ▶ and highlight `NoteText` in the right column.
3. Press VALUE OK to recall the contents of the Note view into the note "Assignments".

15

Programming

Introduction

This chapter describes how to program using the HP 39G/40G. In this chapter you'll learn about:

- using the Program catalog to create and edit programs
- programming commands
- storing and retrieving variables in programs
- programming variables.

HINT More information on programming, including examples and special tools, can be found at HP's calculators web site: **www.hp.com/calculators**

The Contents of a Program

An HP 39G/40G program contains a sequence of numbers, mathematical expressions, and commands that execute automatically to perform a task.

These items are separated by a colon (:). Commands that take multiple arguments have those arguments separated by a semicolon (;). For example,

`PIXON` *xposition*;*yposition*:

Structured Programming

Inside a program you can use branching structures to control the execution flow. You can take advantage of structured programming by creating building-block programs. Each building-block program stands alone—and it can be called from other programs. *Note: If a program has a space in its name then you have to put quotes around it when you want to run it.*

Example

```
RUN GETVALUE: RUN CALCULATE: RUN
"SHOW ANSWER":
```

This program is separated into three main tasks, each an individual program. Within each program, the task can be simple—or it can be divided further into other programs that perform smaller tasks.

Program catalog

The Program catalog is where you create, edit, delete, send, receive, or run programs. This section describes how to

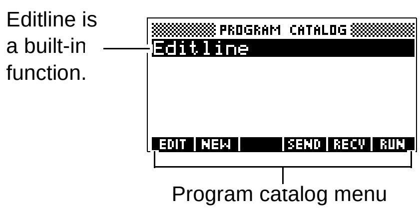
- open the Program catalog
- create a new program
- enter commands from the program commands menu
- enter functions from the MATH menu
- edit a program
- run and debug a program
- stop a program
- copy a program
- send and receive a program
- delete a program or its contents
- customize an aplet.

Open Program catalog

1. Press SHIFT *PROGRM*.

   The Program catalog displays a list of program names. If you haven't created any programs, the only name you'll see is *Editline*.

   Editline contains the last expression that you entered from the edit line in HOME, or the last data you entered in an input form. (If you press ENTER from HOME without entering any data, the HP 39G/40G runs the contents of Editline.)



Before starting to work with programs, you should take a few minutes to become familiar with the Program catalog menu keys. You can use any of the following keys (both menu and keyboard), to perform tasks in the Program catalog.

Program catalog keys

The program catalog keys are:

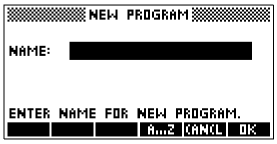
Key	Meaning
EDIT	Opens the highlighted program for editing.
NEW	Prompts for a new program name, then opens an empty program.
SEND	Transmits the highlighted program to another HP 39G/40G or to a disk drive.
RECV	Receives the highlighted program from another HP 39G/40G or from a disk drive.
RUN	Runs the highlighted program.
SHIFT ▲ or ▼	Moves to the beginning or end of the Program catalog.
DEL	Deletes the highlighted program.
SHIFT *CLEAR*	Deletes all programs in the program catalog.

Creating and editing programs

Create a new program

1. Press SHIFT *PROGRM* to open the Program catalog.
2. Press **NEW**.

   The HP 39G/40G prompts you for a name.

   A program name can contain special characters, such as a space. However, if you use special characters and then run the program by typing it in HOME, you must enclose the program name in double quotes (" "). Don't use the " symbol within your program name.

3. Type your program name, then press **OK**.

   When you press **OK**, the Program Editor opens.

4. Enter your program.
   When done, start any other activity. Your work is saved automatically.

Enter commands

Until you become familiar with the HP 39G/40G commands, the easiest way to enter commands is to use the Commands menu from the Program editor. You can always type in commands using alpha characters.

1. From the Program editor, press SHIFT *CMDS* to open the Program Commands menu.

   SHIFT *CMDS*

2. On the left, use ▼ or ▲ to highlight a command category, then press ► to access the commands in the category. Select the command that you want.

   ▼ ▼ ► ▼

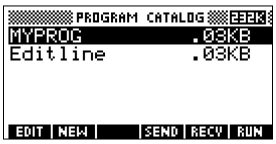
3. Press OK to paste the command into the program editor.

   OK

   To enter functions (more to come)

Edit a program

1. Press SHIFT *PROGRM* to open the Program catalog.



2. Use the arrow keys to highlight the program you want to edit, and press EDIT. The HP 39G/40G opens the Program Editor. The name of your program appears in the title bar of the display. You can use the following keys to edit your program.

Editing keys

The editing keys are:

Key	Meaning
STO▶	Inserts the **STO▶** character at the editing point.
SPACE	Inserts space into text.
▲PAGE	Displays previous page of the program.
PAGE▼	Displays next page of the program.
[▲] [▼]	Moves up or down one line.
[▶] [◀]	Moves right or left one character.
A...Z	Alpha-lock for letter entry. Press [SHIFT] A...Z to lock lower case.
BKSP	Backspaces cursor and deletes character.
[DEL]	Deletes current character.
[ENTER]	Starts a new line.
[SHIFT] *CLEAR*	Erases the entire program.
[VARS] [MATH]	Menus for entering variable names, contents of variables, math functions, and program constants.
[SHIFT] *CMDS*	Menus for entering program conmmands.
[SHIFT] *CHARS*	Displays all characters. To type one, highlight it and press **OK**. To enter several characters in a row, use the **ECHO** menu key while in the *CHARS* menu.

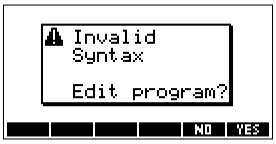
Using programs

Run a program

From HOME, type `RUN` *program_name.*
or
From the Program catalog, highlight the program you want to run and press **RUN**.
Regardless of where you start the program, all programs run in HOME. What you see will differ slightly depending on where you started the program. If you start the program from HOME, the HP 39G/40G displays the contents of *Ans* (Home variable containing the last result), when the program has finished. If you start the program from the Program catalog, the HP 39G/40G returns you to the Program catalog when the program ends.

Debug a program

If you run a program that contains errors, the program will stop and you will see an error message.



To debug the program:

1. Choose **YES** to edit the program.

   The insert cursor appears in the program at the point where the error occurred.

2. Edit the program to fix the error.
3. Re-start the program.
4. Repeat the process until you find and correct all errors.

Stop a program

You can stop the execution of a program at any time by pressing *CANCEL* (the ON key). *Note: You may have to press it a couple of times.*

Working with programs

Copy a program

You can use the following procedure if you want to make a copy of your work before editing—or if you want to use one program as a template for another.

1. Press SHIFT *PROGRM* to open the Program catalog.
2. Press NEW.
3. Type a new file name, then choose OK.

   The Program Editor opens with a new program.
4. Press VARS to open the Variable menu.
5. Press 7 to quickly scroll to Program.
6. Press ▶, then highlight the program you want to copy.
7. Press VALUE, then press OK.

   The contents of the highlighted program are copied into the current program at the cursor location.

HINT If you use a programming routine often, save the routine under a different program name, then use the above method to copy it into your programs.

Transmit a program

You can send programs to, and receive programs from, other calculators just as you can send and receive aplets, matrices, lists, and notes.

After aligning the calculators' infrared ports, open the Program catalogs on both calculators. Highlight the program to send, then press SEND on the sending calculator and RECV on the receiving calculator.

You can also send programs to, and receive programs from, a remote storage device (aplet disk drive or computer). This takes place via a cable connection and requires an aplet disk drive or specialized software running on a PC (such as a connectivity kit).

Delete a program

You can delete any program except Editline.

1. Press SHIFT *PROGRM* to open the Program catalog.
2. Highlight a program to delete, then press DEL.

Delete all programs

You can delete all programs at once.

1. In the Program catalog, press SHIFT *CLEAR*.
2. Press YES.

Delete the contents of a program

You can clear the contents of a program without deleting the program name.

1. Press SHIFT *PROGRM* to open the Program catalog.
2. Highlight a program, then press EDIT.
3. Press SHIFT *CLEAR*, then press YES.
4. The contents of the program are deleted, but the program name remains.

About customizing an aplet

You can configure an aplet and develop a set of programs to work with the aplet.

Use the SETVIEWS command to create a custom VIEWS menu which links specially written programs to the new aplet.

A useful method for customizing an aplet is illustrated below:

1. Decide on the aplet type that you want to use, for example the Function aplet or the Statistics aplet. The copied aplet inherits all the properties of the parent aplet. Save the standard aplet under a new name.
2. Configure the new aplet if you need to, for example by presetting axes or angle measures.
3. Develop the programs to work with your aplet. When you develop the aplet's programs, use the standard aplet naming convention. This allows you to keep track of the programs in the Program catalog that belong to each aplet. See "Aplet naming convention" on page 15-10.
4. Develop a program that uses the SETVIEWS command to modify the aplet's VIEWS menu. The menu options provide links to associated programs. You can specify any other programs that you want transferred with the aplet. See *"SETVIEWS" on page 15-14* for information on the command.
5. Ensure that the new aplet is selected, then run the menu configuration program to configure the aplet's VIEWS menu.
6. Test the aplet and debug the associated programs.(Refer to "Debug a program" on page 15-7).

Aplet naming convention

To assist users in keeping track of aplets and associated programs, use the following naming convention when setting up an aplet's programs:

- Start all program names with an abbreviation of the aplet name. We will use APL in this example.
- Name programs called by menu entries in the VIEWS menu number, after the entry, for example:
  - APL.ME1 for the program called by menu option 1
  - APL.ME2 for the program called by menu option 2
- Name the program that configures the new VIEWS menu option APL.SV where SV stands for SETVIEWS.

For example, a customized aplet called "Differentiation" might call programs called DIFF.ME1, DIFF.ME2, and DIFF.SV.

Customizing an aplet example

This example aplet is designed to demonstrate the process of configuring an aplet. The new aplet is based on the Function aplet. *Note: This aplet is not intended to serve a serious use, merely to illustrate the process.*

Save the aplet

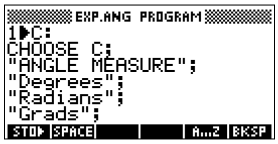
1. Open the Function aplet and save it as "EXPERIMENT". The new aplet appears in the Aplet library.

   [APLET] *Select* `Function` **SAVE**
   [ALPHA] EXPERIMENT
   OK

2. Create a program called EXP.ME1 with contents as shown. This program configures the plot ranges, then runs a program that allows you to configure the angle format.

3. Create a program called EXP.ME2 with contents as shown. This program sets the numeric view options for the aplet, and runs the program that you can use to configure the angle mode.

4. Create a program called EXP.ANG which the previous two programs call.



5. Create a program called EXP.S which runs when you start the aplet, as shown. This program sets the angle mode to degrees, and sets up the initial function that the aplet plots.

Configuring the Setviews menu option programs

In this section we will begin by configuring the VIEWS menu by using the SETVIEWS command. We will then create the “helper” programs called by the VIEWS menu which will do the actual work.

6. Open the Program catalog and create a program named “EXP.SV”. Include the following code in the program. (Text shown in *italics* below are comments only.)

   Each entry line after the command SETVIEWS is a trio that consists of a VIEWS menu text line (a space indicates none), a program name, and a number that defines the view to go to after the program has run its course. All programs listed here will transfer with an aplet when the aplet is transferred.

SETVIEWS ″ ″;; ″ ″;18;

Sets the first menu option to be "Auto scale". This is the fourth standard Function aplet view menu option and the 18 "Auto scale", specifies that it is to be included in the new menu. The empty quotes will ensure that the old name of "Auto scale" appears on the new menu. See *“SETVIEWS” on page 15-14*.

″My Entry1″;″EXP.ME1″;1;

Sets the second menu option. This option runs program EXP.ME1, then returns to view 1, Plot view.

″My Entry2″;″EXP.ME2″;3;

Sets the third menu option. This option runs the program EXP.ME2, then returns to view 3, the NUM view

″ ″;″EXP.SV″;0;

This line specifies that the program to set the View menu (this program) is transferred with the aplet. The space character between the first set of quotes in the trio specifies that no menu option appears for the entry. You do not need to transfer this program with the aplet, but it allows users to modify the aplet’s menu if they want to.

″ ″;″EXP.ANG″;0;

The program EXP.ANG is a small routine that is called by other programs that the aplet uses. This entry specifies that the program.EXP.ANG is transferred when the aplet is transferred, but the space in the first quotes ensures that no entry appears on the menu.

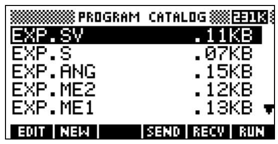
″START″;″EXP.S″;7:

This specifies the Start menu option. The program that is associated with this entry, `.EXP.S,` runs automatically when you start the aplet. Because this menu option specifies view 7, the VIEWS menu opens when you start the aplet.

You only need to run this program once to configure your aplet's VIEWS menu. Once the aplet's VIEWS menu is configured, it remains that way until you run SETVIEWS again.

You do not need to include this program for your aplet to work, but it is useful to specify that the program is attached to the aplet, and transmitted when the aplet is transmitted.

7. Return to the program catalog. The programs that you created should appear as follows:



8. You must now RUN the program EXP.SV to execute the SETVIEWS command and create the modified VIEWS menu. Check that the name of the new aplet is highlighted in the APLET view.

9. You can now return to the APLET library and press START to run your new aplet.

Programming commands

This section describes the commands for programming with HP 39G/40G. You can enter these commands in your program by typing them or by accessing them from the Commands menu.

Aplet commands

These commands control aplets.

CHECK

Checks (selects) the corresponding function in the current aplet. For example, Check 3 would check F3 if the current aplet is Function. Then a checkmark would appear next to F3 in Symbolic view, F3 would be plotted in Plot view, and evaluated in Numeric view.

`CHECK` *n*

SELECT

Selects the named aplet and makes it the current aplet. *Note: Quotes are needed if the name contains spaces or other special characters.*

`SELECT` *apletname*

SETVIEWS

The SETVIEWS command is used to define entries in the VIEWS menu for aplets that you customize. See "About customizing an aplet" on page 15-9 for an example of using the SETVIEWS command.

When you use the SETVIEWS command, the aplet's standard VIEWS menu is deleted and the customized menu is used in its place. You only need to apply the command to an aplet once. The View menu changes remain unless you apply the command again.

Typically, you develop a program that uses the SETVIEWS command only. The command contains a trio of arguments for each menu option to create, or program to attach. Keep the following points in mind when using this command:

- The SETVIEWS command deletes an aplet's standard Views menu options. If you want to use any of the standard options on your reconfigured VIEWS menu, you must include them in the configuration.
- When you invoke the SETVIEWS command, the changes to an aplet's VIEWS menu remain with the aplet. You need to invoke the command on the aplet again to change the VIEWS menu.

- All the programs that are called from the VIEWS menu are transferred when the aplet is transferred, for example to another calculator or to a PC.
- As part of the VIEWS menu configuration, you can specify programs that you want transferred with the aplet, but are not called as menu options. For example, these can be sub-programs that menu options use, or the program that defines the aplet's VIEWS menu.
- You can include a "Start" option in the VIEWS menu to specify a program that you want to run automatically when the aplet starts. This program typically sets up the aplet's initial configuration. The Start option on the menu is also useful for resetting the aplet.

Command syntax

The syntax for the command is as follows:

`SETVIEWS`
`"`*Prompt1*`";"`*ProgramName1*`";`*ViewNumber1*`;`
`"`*Prompt2*`";"`*ProgramName2*`";`*ViewNumber2*`:`
(You can repeat as many *Prompt/ProgramName/ViewNumber* trios of arguments as you like.)

Within each *Prompt/ProgramName/ViewNumber* trio, you separate each item with a semi-colon.

Prompt

Prompt is the text that is displayed for the corresponding entry in the Views menu. Enclose the prompt text in double quotes.

Associating programs with your aplet

If *Prompt* consists of a single space, then no entry appears in the view menu. The program specified in the *ProgramName* item is associated with the aplet and transferred whenever the aplet is transmitted. Typically, you do this if you want to transfer the Setviews program with the aplet, or you want to transfer a sub-program that other menu programs use.

Auto-run programs

If the *Prompt* item is “Start”, then the *ProgramName* program runs whenever you start the aplet. This is useful for setting up a program to configure the aplet. Users can select the Start item from the Views menu to reset the aplet if they change configurations.

You can also define a menu item called “Reset” which is autorun if the user chooses the RESET button in the APLET view.

ProgramName

ProgramName is the name of the program that runs when the corresponding menu entry is selected. All programs that are identified in the aplet’s SETVIEWS command are transferred when the aplet is transmitted.

ViewNumber

V*iewNumber* is the number of a view to start after the program finishes running. For example, if you want the menu option to display the Plot view when the associated program finishes, you would specify 1 as the *ViewNumber* value.

Including standard menu options

To include one of an aplet’s standard View menu options in your customized menu, set up the arguments trio as follows:

- The first argument specifies the menu item name:
  - Leave the argument empty to use the standard Views menu name for the item, or
  - Enter a menu item name to replace the standard name.
- The second argument specifies the program to run:
  - Leave the argument empty to run the standard menu option.
  - Insert a program name to run the program before the standard menu option is selected.
- The third argument specifies the view and the menu number for the item. Determine the menu number from the View numbers table below.

  Note: SETVIEWS with no arguments resets the views to default of the base aplet.

View numbers

The views are numbered as follows:

0	HOME	11	List Catalog
1	Plot	12	Matrix Catalog
2	Symbolic	13	Notepad Catalog
3	Numeric	14	Programs Catalog
4	Plot-Setup	15	Plot-Detail
5	Symbolic-Setup	16	Plot-Table
6	Numeric-Setup	17	Overlay Plot
7	Views	18	Auto scale
8	Note	19	Decimal
9	Sketch view	20	Integer
10	Aplet Catalog	21	Trig

UNCHECK

Unchecks (unselects) the corresponding function in the current aplet. For example, Uncheck 3 would uncheck F3 if the current aplet is Function.

`UNCHECK` *n*

Branch commands

Branch commands let a program make a decision based on the result of one or more tests. Unlike the other programming commands, the branch commands work in logical groups. Therefore, the commands are described together rather than each independently.

IF...THEN...END

Executes a sequence of commands in the *true–clause* only if the *test–clause* evaluates to true. Its syntax is:

`IF` *test–clause*

`THEN` *true–clause* `END`

Example

```
1►A :
IF A==1
 THEN MSGBOX A " EQUALS 1" :
 END
```

IF... THEN... ELSE... END

Executes the *true-clause* sequence of commands if the *test-clause* is true, or the *false-clause* sequence of commands if the *test-clause* is false.

`IF` *test–clause*

`THEN` *true-clause* `ELSE` *false-clause* `END`

Example

```
1►A :
IF A==1
 THEN MSGBOX A " EQUALS 1" :
 ELSE MSGBOX A " IS NOT EQUAL TO 1" :
 END
```

CASE...END

Executes a series of test-clause commands that execute the appropriate *true-clause* sequence of commands. Its syntax is:

CASE
IF *test-clause*$_1$ THEN *true-clause*$_1$ END
IF *test-clause*$_2$ THEN *true-clause*$_2$ END
.
.
.
IF *test-clause*$_n$ THEN *true-clause*$_n$ END
END

When CASE is executed, *test-clause*$_1$ is evaluated. If the test is true, *true-clause*$_1$ is executed, and execution skips to END. If *test-clause*$_1$ if false, execution proceeds to *test-clause*$_2$. Execution with the CASE structure continues until a true-clause is executed (or until all the test-clauses evaluate to false).

IFERR... THEN... END...

Many conditions are automatically recognized by the HP 39G/40G as *error conditions* and are automatically treated as errors in programs.

IFERR...THEN...END allows a program to intercept error conditions that otherwise would cause the program to abort. Its syntax is:

`IFERR` *trap-clause*
`THEN` *error-clause* `END`

RUN

Runs the named program. If your program name contains special characters, such as a space, then you must enclose the file name in double quotes (`" "`).

`RUN` "*program name*" or `RUN` *programname*

STOP

Stops the current program.

`STOP`

Drawing commands

The Drawing commands act on the display. The scale of the display depends on the current aplet's Xmin, Xmax, Ymin, and Ymax values. *The following examples assume the HP 39G/40G default settings with the Function aplet as the current aplet.*

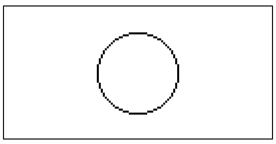
ARC

Draws a circular arc, of given radians, whose centre is at (*x*,*y*) The arc is drawn from *start_angle_measurement*, and *end_angle_measurement*.

`ARC` *x*`;`*y*`;`*radius*`;`*start_angle_measurment*`;` *end_angle_measurment:*

Example

`ARC 0;0;2;0;360:`
`FREEZE:`
Draws a circle centered at (0,0) of radius 2. The FREEZE command causes the circle to remain displayed on the screen until you press a key.



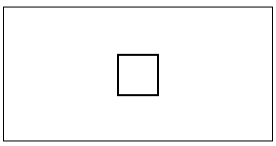
BOX

Draws a box with opposite corners (*x1*,*y1*) and (*x2*,*y2*).

`BOX` *x1*;*y1*;*x2*;*y2*:

Example

`BOX -1;-1;1;1:`
`FREEZE:`
Draws a box, lower corner at (–1,–1), upper corner at (1,1)



ERASE

Clears the display

`ERASE:`

FREEZE

Halts the program, freezing the current display. Execution resumes when any key is pressed.

LINE

Draws a line from (*x1, y1*) to (*x2, y2*).

`LINE` *x1*;*y1*;*x2*;*y2*:

PIXOFF

Turns off the pixel at the specified coordinates (*x*,*y*).

`PIXOFF` *x*`;`*y*:

PIXON

Turns on the pixel at the specified coordinates (*x*,*y*).

`PIXON` *x*`;`*y*:

TLINE

Toggles the pixels along the line from (*x1, y1*) to (*x2, y2*) on and off. Any pixel that was turned off, is turned on; any pixel that was turned on, is turned off. TLINE can be used to erase a line.

`TLINE` *x1*`;`*y1*`;`*x2*`;`*y2*:

Example

`TLINE 0;0;3;3`:
Erases previously drawn 45 degree line from (0,0) to (3,3), or draws that line if it doesn't already exist.

Graphic commands

The Graphic commands use the graphics variables G0 through G9—or the Page variable from Sketch—as *graphicname* arguments. The *position* argument takes the form (*x*,*y*). Position coordinates depend on the current aplet's scale, which is specified by Xmin, Xmax, Ymin, and Ymax. The upper left corner of the target graphic (*graphic2*) is at (Xmin,Ymax).

You can capture the current display and store it in G0 by simultaneously pressing ON + PLOT.

DISPLAY→

Stores the current display in *graphicname*.

`DISPLAY→` *graphicname*

→DISPLAY

Displays graphic from *graphicname* in the display.

`→DISPLAY` *graphicname*

→GROB

Creates a graphic from *expression*, using *font_size*, and stores the resulting graphic in *graphicname*. Font sizes are 1, 2, or 3. If the *fontsize* argument is 0, the HP 39G/40G creates a graphic display like that created by the `SHOW` operation.

→`GROB` *graphicname*`;`*expression*`;`*fontsize*

GROBNOT

Replaces graphic in *graphicname* with bitwise-inverted graphic.

`GROBNOT` *graphicname*

GROBOR

Using the logical OR, superimposes *graphicname2* onto *graphicname1*. The upper left corner of *graphicname2* is placed at *position*.

`GROBOR` *graphicname1*`;`*position*`;` *graphicname2*

GROBXOR

Using the logical XOR, superimposes *graphicname2* onto *graphicname1*. The upper left corner of *graphicname2* is placed at *position*.

`GROBXOR` *graphicname1*`;`*position*`;`*graphicname2*

MAKEGROB

Creates graphic with given width, height, and hexadecimal data, and stores it in *graphicname*.

`MAKEGROB` *graphicname*;*width*;*height;hexdata*

PLOT→

Stores the Plot view display as a graphic in *graphicname*.

`PLOT`→ *graphicname*

`PLOT`→ and `DISPLAY`→ can be used to transfer a copy of the current PLOT view into the sketch view of the aplet for later use and editing.

Example

```
1 ►PageNum:
PLOT→Page:
FREEZE:
```

This program stores the current PLOT view to the first page in the sketch view of the current aplet and then displays the sketch as a graphic object until any key is pressed.

→PLOT

Puts graph from *graphicname* into the Plot view display.

→`PLOT` *graphicname:*

REPLACE

Replaces portion of graphic in *graphicname1* with *graphicname2,* starting at *position*. REPLACE also works for lists and matrices.

REPLACE *graphicname1*;(*position*);*graphicname2:*

SUB

Extracts a portion of the named graphic (or list or matrix), and stores it in a new variable, *name*. The portion is specified by *position* and *positions.*

SUB *name*;*graphicname*;(*position*);(*positions*):

ZEROGROB

Creates a blank graphic with given *width* and *height*, and stores it in *graphicname*.

ZEROGROB *graphicname*;*width*;*height:*

Loop commands

Loop structures allow a program to execute a routine repeatedly. The HP 39G/40G has three loop structures. The example programs below illustrate each of these structures incrementing the variable A from 1 to 12.

DO…UNTIL …END

Do ... Until ... End is a loop structure that executes the *loop-clause* repeatedly until *test-clause* returns a true (nonzero) result. Because the test is executed *after* the loop-clause, the loop-clause is always executed at least once. Its syntax is:

DO *loop-clause* UNTIL *test-clause* END

```
1 ► A:
DO A + 1 ► A
UNTIL A == 12
END
```

WHILE… REPEAT… END

While ... Repeat ... End is a loop structure that repeatedly evaluates *test-clause* and executes *loop-clause* sequence if the test is true. Because the test-clause is executed before the loop-clause, the loop-clause is not executed if the test is initially false. Its syntax is:

WHILE *test-clause* REPEAT *loop-clause* END

```
1 ► A:
WHILE A < 12
REPEAT A+1 ► A
END
```

FOR…TO…STEP ...END

`FOR` *name*=*start-expression* `TO` *end-expression* `[STEP` *increment*`];`

loop-clause `END`

```
FOR A=1 TO 12 STEP 1;
DISP 3;A:
END
```

Note that the STEP parameter is optional. If it is omitted, a step value of 1 is assumed.

BREAK

Terminates loop.

```
BREAK
```

Matrix commands

The matrix commands take variables M0–M9 as arguments.

ADDCOL

Add Column. Inserts *values* into a column before *column_number* in the specified matrix. You enter the *values* as a vector. The values must be separated by commas and the number of values must be the same as the number of rows in the matrix *name*.

`ADDCOL` *name*`;[`*value1,...,*$value_n$`];`*column_number*

ADDROW

Add Row. Inserts *values* into a row before *row_number* in the specified matrix. You enter the values as a vector. The values must be separated by commas and the number of values must be the same as the number of columns in the matrix *name*.

`ADDROW` *name*`;[`$value_1$`, ...,` $value_n$`];`*row_number*

DELCOL

Delete Column. Deletes the specified column from the specified matrix.

`DELCOL` *name*`;`*column_number*

DELROW

Delete Row. Deletes the specified row from the specified matrix.

`DELROW` *name*`;`*row_number*

EDITMAT

Starts the Matrix Editor and displays the specified matrix. If used in programming, returns to the program when user presses OK.

`EDITMAT` *name*

RANDMAT

Creates random matrix with a specified number of rows and columns and stores the result in *name* (*name* must be `M0...M9`). The entries will be integers ranging from –9 to 9.

`RANDMAT` *name*`;`*rows*`;`*columns*

REDIM

Redimensions the specified matrix or vector to *size*. For a matrix, *size* is a list of two integers {*n1*,*n2*}. For a vector, *size* is a list containing one integer {*n*}.

`REDIM` *name*`;`*size*

REPLACE

Replaces portion of a matrix or vector stored in *name* with an object starting at position *start*. *start* for a matrix is a list containing two numbers; for a vector, it is a single number. Replace also works with lists and graphics.

`REPLACE` *name*`;`*start*`;`*object*

SCALE

Multiplies the specified *row_number* of the specified matrix by *value*.

`SCALE` *name*`;`*value*`;`*rownumber*

SCALEADD

Multiplies the row of the matrix *name* by *value*, then adds this result to the second specified row.

`SCALEADD` *name*`;`*value*`;`*row1*`;`*row2*

SUB

Extracts a *sub-object*—a portion of a list, matrix, or graphic from *object*—and stores it into *name*. *start* and *end* are each specified using a list with two numbers for a matrix, a number for vector or lists, or an ordered pair, (X,Y), for graphics.

`SUB` *name*`;`*object*`;`*start*`;`*end*

SWAPCOL

Swaps Columns. Exchanges *column1* and *column2* of the specified matrix.

`SWAPCOL` *name*`;`*column1*`;`*column2*

SWAPROW

Swap Rows. Exchanges *row1*and *row2* in the specified matrix.

`SWAPROW` *name*`;`*row1*`;`*row2*

Print commands

These commands print to an HP infrared printer, for example the HP 82240B printer. *Note: The HP 40G does not have an infrared port and will not print to an infrared printer.*

PRDISPLAY

Prints the contents of the display.

`PRDISPLAY`

PRHISTORY

Prints all objects in the history.

`PRHISTORY`

PRVAR

Prints name and contents of *variablename*.

`PRVAR` *variablename*

You can also use the PRVAR command to print the contents of a program or a note.

`PRVAR` *programname*`;PROG`

`PRVAR` *notename*`;NOTE`

Prompt commands

You can use the following commands to prompt users for input during your program or to provide information to users.

BEEP

Beeps at the frequency and for the time you specify.

`BEEP` *frequency*`;`*seconds*

CHOOSE

Creates a Choose Box, which is a box containing a list of options from which the user chooses one. Each option is numbered, 1 through *n*. The result of the choose command is to store the number of the option chosen in a variable. The syntax is

`CHOOSE` *default_option_number*; *title*; $option_1$; $option_2$; ...$option_n$

where *default_option_number* is the number of the option that will be highlighted by default whenever the Choose Box is displayed, *title* is the text displayed in the title bar of the Choose Box, and $option_1$...$option_n$ are the options listed in the Choose Box.

Example

```
3 ►A:CHOOSE A;
"COMIC STRIPS";
"DILBERT";
"CALVIN&HOBBES";
"BLONDIE";
```

DISP

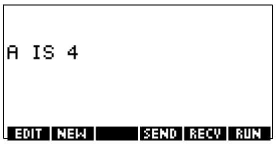
Displays *textitem* in a row of the display at the *line_number*. A text item consists of any number of expressions and quoted strings of text. The expressions are evaluated and turned into strings. Lines are numbered from the top of the screen, 1 being the top and 7 being the bottom.

`DISP` *line_number;textitem*

Example

DISP 3;"A is" 2+2

Result: `A is 4`
(displayed on line 3)



DISPTIME

Displays the current date and time.

DISPTIME

To set the date and time, simply store the correct settings in the date and time variables. Use the following formats: `M.DDYYYY` for the date and `H.MMSS` for the time.

Examples

`5.152000 ►DATE(`sets the date to May 15, 2000).

`10.1500 ►TIME` (sets the time to 10:15 am).

EDITMAT

Matrix Editor. Opens the Matrix editor for the specified matrix. Returns to the program when user presses OK

`EDITMAT` *matrixname*

The `EDITMAT` command can also be used to create matrices.

1. Press [SHIFT] *CMDS* [)] [►] [SIN] OK
2. Press [ALPHA] *M* 1, and then press [ENTER].
3. The Matrix catalog opens with M1 available for editing.

   `EDITMAT` *matrixname* is a shortcut to opening the matrix editor with *matrixname*.

FREEZE

This command prevents the display from being updated after the program runs. This allows you to view the graphics created by the program. Cancel `FREEZE` by pressing any key.

`FREEZE`

GETKEY

Waits for a key, then stores the keycode rc.p in *name,* where r is row number, c is column number, and p is key-plane number. The key-planes numbers are: 1 for unshifted; 2 for shifted; 4 for alpha-shifted; and 5 for both alpha-shifted and shifted.

`GETKEY` *name*

INPUT

Creates an input form with a title bar and one field. The field has a label and a default value. There is text help at the bottom of the form. The user enters a value and presses the OK menu key. The value that the user enters is stored in the variable *name*. The *title*, *label*, and *help* items are text strings and need to be enclosed in double quotes.

Use SHIFT *CHARS* to type the quote marks " ".

`INPUT` *name*`;`*title*`,`*label*`;`*help*`;`*default*

Example

```
INPUT R; "Circular Area";
      "Radius";
      "Enter Number";1:
```

MSGBOX

Displays a message box containing *textitem.* A text item consists of any number of expressions and quoted strings of text. The expressions are evaluated and turned into strings of text. For example,
`"AREA IS:"` 2+2 becomes `AREA IS: 4`. Use SHIFT *CHARS* to type the quote marks " ".

`MSGBOX` *textitem*`:`

Example

```
1 ► A:
MSGBOX "AREA IS: "π*A^2:
```

You can also use the NoteText variable to provide text arguments. This can be used to insert line breaks. For example, press SHIFT *NOTE* and type `AREA IS` ENTER.

The position line

```
MSGBOX NoteText " " π*A^2:
```

will display the same message box as the previous example.

PROMPT

Displays an input box with *name* as the title, and prompts for a value for *name*. *name* can only be one character in length.

`PROMPT` *name*

WAIT

Halts program execution for the specified number of seconds.

`WAIT` *seconds*

Stat-One and Stat-Two commands

The following commands are used for analysis of one-variable and two-variable statistical data.

Stat-One commands

DO1VSTATS

Calculates STATS using *datasetname* and stores the results in the corresponding variables: NΣ, TotΣ, MeanΣ, PVarΣ, SVarΣ, PSDev, SSDev, MinΣ, Q1, Median, Q3, and MaxΣ. *Datasetname* can be H1, H2, ..., or H5. *Datasetname* must define at least two data points.

`DO1VSTATS` *datasetname*

SETFREQ

Defines *datasetname* frequency according to *column* or value. *Datasetname* can be H1, H2,..., or H5, *column* can be C0–C9 and value can be any positive integer.

`SETFREQ` *datasetname*`;`*column*

or

`SETFREQ` *definition*`;`*value*

SETSAMPLE

Defines *datasetname* sample according to *column. Datasetname* can be H1–H5, and column can be CO–C9.

`SETSAMPLE` *datasetname*`;`*column*

Stat-Two commands

DO2VSTATS

Calculates STATS using *datasetname* and stores the results in corresponding variables: MeanX, ΣX, ΣX2, MeanY, ΣY, ΣY2, ΣXY, Corr, PCov, SCov, and RELERR. *Datasetname* can be SI, S2,..., or S5. *Datasetname* must define at least four pairs of data points.

`DO2VSTATS` *datasetname*

SETDEPEND

Defines *datasetname* dependent *column*. *Datasetname* can be S1, S2, …, or S5 and *column* can be C0–C9.

`SETDEPEND` *datasetname*`;`*column*

SETINDEP

Defines *datasetname* independent *column*. *Datasetname* can be S1, S2,…, or S5 and *column* can be C0–C9.

`SETINDEP` *datasetname*`;`*column*

Storing and retrieving variables in programs

The HP 39G/40G has both *Home* variables and *Aplet* variables. Home variables are used for real numbers, complex numbers, graphics, lists, and matrices. Home variables keep the same values in HOME and in aplets.

Aplet variables are those whose values depend on the current aplet. The aplet variables are used in programming to emulate the definitions and settings you make when working with aplets interactively.

You use the Variable menu (VARS) to retrieve either Home variables or aplet variables. See "The VARS menu" on page 11-4. Not all variables are available in every aplet. S1fit–S5fit, for example, are only available in the Statistics aplet.
Under each variable name is a list of the aplets where the variable can be used.

Plot-view variables

The following aplet variables control the Plot view.

Area
Function

Contains the last value found by the Area function in Plot-FCN menu.

Axes
All Aplets

Turns axes on or off.

From Plot Setup, check (or uncheck) `_AXES`.

or

In a program, type:

`1 ► Axes`—to turn axes on (default).
`0 ► Axes`—to turn axes off.

Connect
Function
Parametric
Polar
Solve
Statistics

Draws lines between successively plotted points.

From Plot Setup, check (or uncheck) `_CONNECT`.

or

In a program, type

`1 ► Connect`—to connect plotted points (default, except in Statistics where the default is off).
`0 ► Connect`—not to connect plotted points.

Coord

Function
Parametric
Polar
Sequence
Solve
Statistics

Turns the coordinate-display mode in Plot view on or off.

From Plot view, use the Menu mean key to toggle coordinate display on an off.

In a program, type

`1 ► Coord`—to turn coordinate display on (default).
`0 ► Coord`—to turn coordinate display off.

Extremum

Function

Contains the last value found by the Extremum operation in the Plot-FCN menu.

FastRes

Function
Solve

Toggles resolution between plotting in every other column (faster), or plotting in every column (more detail).

From Plot Setup, choose Faster or More Detail.

or

In a program, type

`1 ► FastRes`—for faster (default).
`0 ► FastRes`—for more detail.

Grid

All Aplets

Turns the background grid in Plot view on or off. From Plot setup, check (or uncheck) `_GRID`.

or

In a program, type

`1 ► Grid` to turn the grid on.
`0 ► Grid` to turn the grid off (default).

Hmin/Hmax

Statistics

Defines minimum and maximum values for histogram bars.

From Plot Setup for one-variable statistics, set values for `HRNG`.

or

In a program, type

n_1 `► Hmin`

n_2 `► Hmax`

where $n_2 > n_1$

Hwidth
Statistics

Sets the width of histogram bars.

From Plot Setup in 1VAR stats set a value for `Hwidth`

or

In a program, type

n ► `Hwidth`

Indep
All Aplets

Defines the value of the independent variable used in tracing mode.

In a program, type

n ► `Indep`

InvCross
All Aplets

Toggles between solid crosshairs or inverted crosshairs. (Inverted is useful if the background is solid).

From Plot Setup, check (or uncheck) `_InvCross`

or

In a program, type:

`1 ► InvCross`—to invert the crosshairs.
`0 ► InvCross` —for solid crosshairs (default).

Isect
Function

Contains the last value found by the Intersection function in the Plot-FCN menu.

Labels
All Aplets

Draws labels in Plot view showing X and Y ranges.

From Plot Setup, check (or uncheck) `_Labels`

or

In a program, type

`1 ►Labels`—to turn labels on.
`0 ►Labels`—to turn labels off (default).

Nmin / Nmax
Sequence

Defines the minimum and maximum independent variable values. Appears as the `NRNG` fields in the Plot Setup input form.

From Plot Setup, enter values for `NRNG`.

or

In a program, type

n_1 ►`Nmin`

n_2 ►`Nmax`

`where` $n_2 > n_1$

Recenter
All Aplets

Recenters at the crosshairs locations when zooming.

From Plot-Zoom-Set Factors, check (or uncheck) _ `Recenter`

or

In a program, type

`1 ► Recenter`— to turn recenter on (default).
`0 ► Recenter`—to turn recenter off.

Root
Function

Contains the last value found by the `Root` function in the Plot-FCN menu.

S1mark–S5mark
Statistics

Defines the mark to use for statistics 2-variable scatter plots.

From Plot Setup for two-variable statistics, `S1mark-S5mark`, then choose a mark.

or

In a program, type

```
n ► S1mark
where n is 1,2,3,...5
```

SeqPlot
Sequence

Toggles type of sequence plot: Stairstep or Cobweb.

From Plot Setup, select `SeqPlot`, then choose `Stairstep` or `Cobweb`.

or

In a program, type

`1 ► SeqPlot`—for stairstep.

`2 ► SeqPlot`—for cobweb.

Simult
Function
Parametric
Polar
Sequence

Toggles between simultaneous and sequential graphing of all selected expressions.

From Plot Setup, check (or uncheck) `_SIMULT`

or
In a program, type

`1 ► Simult`—for simultaneous graphing.
`0 ► Simult`—for sequential graphing.

Slope
Function

Contains the last value found by the Slope function in the Plot–FCN menu.

StatPlot
Statistics

Toggles type of 1–variable statistics plot between Histogram or Box–and–Whisker.

From Plot Setup, select `StatPlot`, then choose `Histogram` or `BoxWhisker`.

or

In a program, type

`1 ► StatPlot`—for Histogram.

`2 ► StatPlot`—for BoxWhisker.

Umin/Umax
Polar

Defines the minimum and maximum independent values. Appears as the `URNG` field in the Plot Setup input form.

From the Plot Setup input form, enter values for `URNG`.

or

In a program, type

n_1 ► `Umin`

n_2 ► `Umax`

where $n_2 > n_1$

Ustep
Polar

Defines the step size for an independent variable.

From the Plot Setup input form, enter values for `USTEP`.

or

In a program, type

n ► `Ustep`

where $n > 0$

Tmin / Tmax

Parametric

Defines the minimum and maximum independent variable values. Appears as the TRNG field in the Plot Setup input form.

From Plot Setup, enter values for TRNG.

or

In a program, type

n_1 ► Tmin

n_2 ► Tmax

where $n_2 > n_1$

Tracing

All Aplets

Turns tracing mode on or off in Plot view.

In a program, type

1 ► Tracing—to turn Tracing mode on (default).
0 ► Tracing—to turn Tracing mode off.

Tstep

Parametric

Defines the step size for an independent variable.

From the Plot Setup input form, enter values for TSTEP.

or

In a program, type

n ► Tstep

where $n > 0$

Xcross

All Aplets

Defines the horizontal coordinate of crosshairs. Only works with TRACE off.

In a program, type

n ► Xcross

Ycross

All Aplets

Defines the vertical coordinate of crosshairs. Only works with TRACE off.

In a program, type

n ► Ycross

Xtick
All Aplets

Defines the distance between tick marks for the horizontal axis.

From the Plot Setup input form, enter a value for `Xtick`.

or

In a program, type

n ► `Xtick` where $n > 0$

Ytick
All Aplets

Defines the distance between tick marks for the vertical axis.

From the Plot Setup input form, enter a value for `Ytick`.

or

In a program, type

n ► `Ytick` where $n > 0$

Xmin / Xmax
All Aplets

Defines the minimum and maximum horizontal values of the plot screen. Appears as the `XRNG` fields (horizontal range) in the Plot Setup input form.

From Plot Setup, enter values for `XRNG`.

or

In a program, type

n_1 ► `Xmin`

n_2 ► `Xmax`

where $n_2 > n_1$

Ymin / Ymax
All Aplets

Defines the minimum and maximum vertical values of the plot screen. Appears as the `YRNG` fields (vertical range) in the Plot Setup input form.

From Plot Setup, enter the values for `YRNG`.

or

In a program, type

n_1 ► `Ymin`

n_2 ► `Ymax`

where $n_2 > n_1$

Xzoom

All Aplets

Sets the horizontal zoom factor.

From Plot-ZOOM-Set Factors, enter the value for `XZOOM`.

or

In a program, type

n ► `XZOOM`
where $n > 0$

Yzoom

All Aplets

Sets the vertical zoom factor.

From Plot-ZOOM-Set Factors, enter the value for `YZOOM`.

or
In a program, type

n ► `YZOOM`

Symbolic-view variables

The following aplet variables available in the Symbolic view.

Angle

All Aplets

Sets the angle mode.

From Symbolic Setup, choose `Degrees`, `Radians`, or `Grads` for angle measure.

or

In a program, type

1 ► `Angle` —for Degrees.

2 ► `Angle` —for Radians.

3 ► `Angle`—for Grads.

F1...F9, F0

Function

Can contain any expression. Independent variable is *X*.

Example

`'SIN(X)' ► F1(X)`

In the above example, you must put single quotes around the expression to keep it from being evaluated before it is stored. Use SHIFT *CHARS* to type the single quote mark.

X1, Y1...X9,Y9 X0,Y0
Parametric

Can contain any expression. Independent variable is T.

Example

```
'SIN(4*T)' ► Y1(T):'2*SIN(6*T)' STO►
X1(T)
```

R1...R9, R0
Polar

Can contain any expression. Independent variable is θ.

Example

```
'2*SIN(2*θ)' ► R1(θ)
```

U1...U9, U0
Sequence

Can contain any expression. Independent variable is N.

Example

```
RECURSE (U,U(N-1)*N,1,2) ► U1(N)
```

E1...E9, E0
Solve

Can contain any equation or expression. *Independent variable is selected by highlighting it in Numeric View.*

Example

```
'X+Y*X-2=Y' ► E1
```

S1fit...S5fit
Statistics

Defines the type of fit to be used by the FIT operation in drawing the regression line.

From Symbolic Setup view, specify the fit in the field for S1FIT, S2FIT, etc.
or
In a program, store one of the following constant names or numbers into a variable `S1fit`, `S2fit`, etc.

1. `Linear`
2. `LogFit`
3. `ExpFit`
4. `Power`
5. `QuadFit`
6. `Cubic`
7. `Logist`
8. `User defined`

Example

```
Cubic ► S2fit
```

or

```
6 ► S2fit
```

Numeric-view variables

The following aplet variables control the Numeric view. The value of the variable applies to the current aplet only.

C1...C9, C0
Statistics

`C0` through `C9`, for columns of data. Can contain lists.

Enter data in the Numeric view

or

In a program, type

`LIST ►C`*n*

where *n* = `0, 1, 2, 3 ... 9`

Digits
All Aplets

Number of decimal places to use for Number format.

From Solve's Numeric Setup view, enter a value in the second field of `Number Format`.

or

In a program, type

n ► `Digits`

where $0 < n < 11$

Except in `Solve`, the value of `Digits` takes effect only after the current aplet is saved with a new name. Until then, `HDigit` is in effect.

Format

All Aplets

Defines the number display format.

From Solve's Numeric Setup view, choose `Standard`, `Fixed`, `Scientific`, or `Engineering` in the `Number Format` field.

or

In a program, store the constant name (or its number) into the variable `Format`.

1. `Standard`
2. `Fixed`
3. `Scientific`
4. `Engineering`

Note: Fraction is not a valid mode in aplets.

Except in Solve, the value of Format takes effect only after the current aplet is saved with a new name. Until then, `HFormat` is in effect.

Example

`Scientific ► Format`

or

`3 ► Format`

NumCol

All Aplets except Statistics aplet

Defines the highlighted column in Numeric view.

In a program, type

n ► `NumCol`

where *n* can be 0, 1, 2, 3, 4, 5, 6, 7, 8, 9.

NumFont

Function
Parametric
Polar
Sequence
Statistics

Toggles the font size in Numeric view. Does not appear in the Num Setup input form. Corresponds to the BIG key in Numeric view.

In a program, type

`0 ► NumFont` for small (default).
`1 ► NumFont` for big.

NumIndep

Function
Parametric
Polar
Sequence

List of independent values used by Build Your Own Table.

In a program, type

`LIST ► NumIndep`

NumRow
All Aplets except Statistics aplet

Defines the highlighted row in Numeric view.

In a program, type

n ► `NumRow`

where $n > 0$

NumStart
Function
Parametric
Polar
Sequence

Defines the starting value for a table in Numeric view.

From Num Setup, enter a value for `NUMSTART`.

or

In a program, type

n ► `NumStart`

NumStep
Function
Parametric
Polar
Sequence

Defines the step size (increment value) for an independent variable in Numeric view.

From Num Setup, enter a value for `NUMSTEP`.

or

In a program, type

n ► `NumStep`
where $n > 0$

NumType
Function
Parametric
Polar
Sequence

Choose a table format.

From Num Setup, choose `Automatic` or `Build Your Own`.

or

In a program, type

`0` ► `NumType` for Build Your Own.
`1` ► `NumType` for Automatic (default).

NumZoom
Function
Parametric
Polar
Sequence

Defines the Zoom factor in the Numeric view.

From Num Setup, type in a value for `NUMZOOM`.

or

In a program, type

n ► `NumZoom`
where $n > 0$

StatMode
Statistics

Toggles between 1–variable and 2–variable statistics in the Statistics aplet. Does not appear in the Plot Setup input form. Corresponds to the 1VAR and 2VAR menu keys in Numeric View.

In a program, store the constant name (or its number) into the variable StatMode. `1VAR=1`, `2VAR=2`.

Example

```
1VAR ► StatMode
```

or

```
1 ► StatMode
```

Note variables

The following aplet variable is available in Note view.

NoteText
All Aplets

Use NoteText to recall text previously entered in Note view.

Sketch variables

The following aplet variables are available in Sketch view.

Page
All Aplets

Defines a *page* in a sketch set. A sketch set can contain up to 10 graphics. The graphics can be viewed one at a time using the ◄PAGE and PAGE► keys.

The Page variable refers to the currently displayed page of a sketch set.

In a program, type

graphicname ► `Page`

PageNum
All Aplets

Index for referring to a particular page of the sketch set (in Sketch view).

In a program, type the page that is shown when SHIFT *SKETCH* is pressed.

n ► `PageNum`

16

Extending aplets

Aplets are the application environments where you explore different classes of mathematical operations.

You can extend the capability of the HP 39G/40G in the following ways:

- Create new aplets, based on existing aplets, with specific configurations such as angle measure, graphical or tabular settings, and annotations.
- Transmit aplets between HP 39G calculators via an infra red link.
- Download e-lessons (teaching aplets) from the Hewlett-Packard's Calculator web site.
- Program new aplets. See chapter 15, Programming, for further details.

Creating new aplets based on existing aplets

You can create a new aplet based on an existing aplet. To create a new aplet, save an existing aplet under a new name, then modify the aplet to add the configurations and the functionality that you want. You can send your aplet to other calculators so that other people can use it.

Information that defines an aplet is saved automatically as it is entered into the calculator.

To keep as much memory available for storage as possible, delete any aplets you no longer need.

Aplet Keys

Key	Meaning
SAVE	Saves the highlighted aplet with a name.
RESET	Resets the default values and settings in the highlighted aplet. This erases any stored data or functions.
SORT	Alphabetically or chronologically sorts the items in the Aplet Library menu list.
SEND	Transmits the highlighted aplet to another HP 39G/40G or a storage device.
RECV (receive)	Receives the aplet sent from another HP 39G/40G or storage device.
START (or ENTER)	Opens the selected aplet.

Example: To create a new aplet from an existing Solve aplet

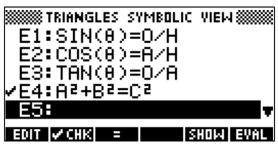
A simple example of a customized aplet is the TRIANGLES aplet. This aplet is a copy of the Solve aplet containing the formulas commonly used in calculations involving right–angled triangles.

1. In APLET, highlight `Solve` and SAVE it under the new name.

   APLET *Select* `Solve`
   SAVE ALPHA
   T R I A N G L E S
   ENTER START

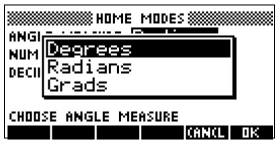
2. Enter the four formulas:

   SIN ALPHA θ
) = ALPHA O
   ÷ ALPHA H ENTER
   COS ALPHA θ) =
   ALPHA A ÷
   ALPHA H ENTER
   TAN ALPHA θ) =
   ALPHA O ÷ ALPHA A ENTER
   ALPHA A X² + ALPHA B X²
   = ALPHA C X² ENTER



3. Decide whether you want the aplet to operate in Degrees, Radians, or Grads.

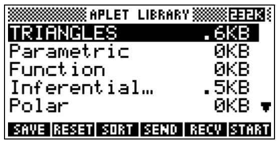
   SHIFT *MODES*
   CHOOS
   Select `Degrees`
   OK



4. Ensure the TRIANGLES aplet is saved in the Aplet Library.

   APLET

   The Solve aplet can now be reset and used for other problems.



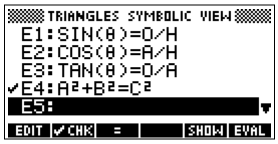
Example: To use the customized aplet

To use the aplet, simply select the appropriate formula, change to the Numeric view and solve for the missing variable.

Find the length of a ladder leaning against a vertical wall if it forms an angle of 35^o with the horizontal and extends 5 metres up the wall.

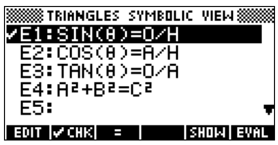
1. Select the aplet.

   APLET *Select* `TRIANGLES`
   START



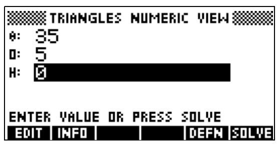
2. Choose the sine formula in E1.

   ▲ ▲ ▲ ▲ ✓CHK



3. Change to the Numeric view and enter the known values.

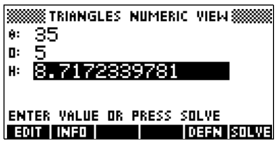
   NUM
   35 ENTER
   5 ENTER



4. Solve for the missing value.

   SOLVE

   The length of the ladder is approximately 8.72 metres



Resetting an aplet

Resetting an aplet clears all data and resets all default settings.

To reset an aplet, open the Library, select the aplet and press RESET.

You can only reset an aplet that is based on a built-in aplet if the programmer who created it has provided a Reset option.

Annotating an aplet with notes

The Note view (SHIFT *NOTE*) attaches a note to the current aplet. See Chapter 14, “Notes and Sketches.”

Annotating an aplet with sketches

The Sketch view (SHIFT *SKETCH*) attaches a picture to the current aplet. See chapter 14, “Notes and sketches”.

HINT Notes and sketches that you attach to an aplet become part of the aplet. When you transfer the aplet to another calculator, the associated note and sketch are transferred as well.

Downloading e-lessons from the web

In addition to the standard aplets that come with the calculator, you can download aplets from the world wide web. For example, Hewlett-Packard’s Calculators web site contains aplets that demonstrate certain mathematical concepts. Note that you need the Graphing Calculator Connectivity Kit in order to load aplets from a PC.

Hewlett-Packard’s Calculators web site can be found at:

www.hp.com/calculators

Sending and receiving aplets

A convenient way to distribute or share problems in class and to turn in homework is to transmit (copy) aplets directly from one HP 39G to another. This takes place via the infrared port.

You can also send aplets to, and receive aplets from, a remote storage device (aplet disk drive or computer). This takes place via a cable connection and requires an aplet disk drive or special software running on a PC (such as the PC Connectivity Kit). *Note: The HP 40G does not have an IR port. A PC adapter and unit–to–unit cable is supplied instead.*

To transmit an aplet

1. Connect the storage device to the calculator by cable
   or
   align the two calculators' infrared ports by matching up the triangle marks on the rims of the calculators. Place the calculators no more than 2 inches (5 cm) apart.

2. Sending calculator: Open the Library, highlight the aplet to send, and press **SEND**.
   - You have two options: another HP 39G or a disk drive on a PC. Highlight your selection and press **OK**.
   - If transmitting to a disk drive, you have the options of sending to the current (default) directory or to another directory.

3. Receiving calculator: Open the aplet library and press **RECV**.
   - You have two options: another HP 39G or a disk drive (or computer). Highlight your selection and press **OK**.

   The Transmit annunciator——is displayed until transmission is complete.

If you are using the PC Connectivity Kit to download aplets from a PC, you will see a list of aplets in the PC's current directory. Check as many items as you would like to receive.

Sorting items in the aplet library menu list

Once you have entered information into an aplet, you have defined a new version of an aplet. The information is automatically saved under the current aplet name, such as "Function." To create additional aplets of the same type, you must give the current aplet a new name.

The advantage of storing an aplet is to allow you to keep a copy of a working environment for later use.

The aplet library is where you go to manage your aplets. Press APLET. Highlight (using the arrow keys) the name of the aplet you want to act on.

To sort the aplet list

In the aplet library, press SORT. Select the sorting scheme and press ENTER.

- `Chronologically` produces a chronological order based on the date an aplet was last used. (The last-used aplet appears first, and so on.)
- `Alphabetically` produces an alphabetical order by aplet name.

To delete an aplet

You cannot delete a built-in aplet. You can only clear its data and reset its default settings.

To delete a customized aplet, open the aplet library, highlight the aplet to be deleted, andess DEL. To delete all custom aplets, press SHIFT *CLEAR*.

Reference information

Regulatory information

This section contains information that shows how the HP 39G/40G 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 39G/40G 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).

LED safety

The infrared port located on the top of the calculator is classified as a Class 1 LED (light emitting diode) device according to International Standard IEC 825-1 (EN 60825-1. This device is not considered harmful, but the following precautions are recommended:

- Do not attempt to make any adjustments to the unit.
- Avoid direct eye exposure to the infrared LED beam. Be aware that the beam is invisible light and cannot be seen.
- Do not attempt to view the infrared LED beam with any type of optical device.

CLASS 1 LED PRODUCT LEDSCHÜTZKLASSE 1 PRODUKT

Warranty

HP 39G/40G Graphical Calculator
Warranty period: 12 months

1. HP warrants to you, the end-user customer, that HP hardware, accessories and supplies will be free from defects in materials and workmanship after the date of purchase, for the period specified above. If HP receives notice of such defects during the warranty period, HP will, at its option, either repair or replace products which prove to be defective. Replacement products may be either new or like-new.
2. HP warrants to you that HP software will not fail to execute its programming instructions after the date of purchase, for the period specified above, due to defects in material and workmanship when properly installed and used. If HP receives notice of such defects during the warranty period, HP will replace software media which does not execute its programming instructions due to such defects.

3. HP does not warrant that the operation of HP products will be uninterrupted or error free. If HP is unable, within a reasonable time, to repair or replace any product to a condition as warranted, you will be entitled to a refund of the purchase price upon prompt return of the product.
4. HP products may contain re manufactured parts equivalent to new in performance or may have been subject to incidental use.
5. Warranty does not apply to defects resulting from (a) improper or inadequate maintenance or calibration, (b) software, interfacing, parts or supplies not supplied by HP, (c) unauthorized modification or misuse, (d) operation outside of the published environmental specifications for the product, or (e) improper site preparation or maintenance.
6. HP MAKES NO OTHER EXPRESS WARRANTY OR CONDITION WHETHER WRITTEN OR ORAL. TO THE EXTENT ALLOWED BY LOCAL LAW, ANY IMPLIED WARRANTY OR CONDITION OF MERCHANTABILITY, SATISFACTORY QUALITY, OR FITNESS FOR A PARTICULAR PURPOSE IS LIMITED TO THE DURATION OF THE EXPRESS WARRANTY SET FORTH ABOVE. Some countries, states or provinces do not allow limitations on the duration of an implied warranty, so the above limitation or exclusion might not apply to you. This warranty gives you specific legal rights and you might also have other rights that vary from country to country, state to state, or province to province.
7. TO THE EXTENT ALLOWED BY LOCAL LAW, THE REMEDIES IN THIS WARRANTY STATEMENT ARE YOUR SOLE AND EXCLUSIVE REMEDIES. EXCEPT AS INDICATED ABOVE, IN NO EVENT WILL HP OR ITS SUPPLIERS BE LIABLE FOR LOSS OF DATA OR FOR DIRECT, SPECIAL, INCIDENTAL, CONSEQUENTIAL (INCLUDING LOST PROFIT OR DATA), OR OTHER DAMAGE, WHETHER BASED IN CONTRACT, TORT, OR OTHERWISE. Some countries, States or provinces do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

8. FOR CONSUMER TRANSACTIONS IN AUSTRALIA AND NEW ZEALAND: THE WARRANTY TERMS CONTAINED IN THIS STATEMENT, EXCEPT TO THE EXTENT LAWFULLY PERMITTED, DO NOT EXCLUDE, RESTRICT OR MODIFY AND ARE IN ADDITION TO THE MANDATORY STATUTORY RIGHTS APPLICABLE TO THE SALE OF THIS PRODUCT TO YOU.

CAS

The HP 40G is packaged with a computerized algebra system (CAS). Refer to the CAS User Manual for further information.

Resetting the HP 39G/40G

If the calculator "locks up" and seems to be stuck, you must **reset** it. This is much like resetting a PC. It cancels certain operations, restores certain conditions, and clears temporary memory locations. However, it does *not* clear stored data (variables, aplet databases, programs) *unless* you use the procedure below, "To erase all memory and reset defaults".

To reset using the keyboard

Press and hold the ON key and the third menu key simultaneously, then release them.

If the calculator does not respond to the above key sequence, then:

1. Turn the calculator over and locate the small hole in the back of the calculator.
2. Insert the end of a straightened metal paper clip into the hole as far as it will go. Hold it there for 1 second, then remove it.
3. Press ON. If necessary, press ON and the first and last menu keys simultaneously.

To erase all memory and reset defaults

If the calculator does not respond to the above resetting procedures, you might need to restart it by erasing all of memory. *You will lose everything you have stored.* All factory-default settings are restored.

1. Press and hold the ON key, the first menu key, and the last menu key simultaneously.
2. Release all keys.

   *Note: To **cancel** this process, release **only** the top-row keys, then press the third menu key.*

If the calculator does not turn on

If the HP 39G/40G does not turn on follow the steps below until the calculator turns on. You may find that the calculator turns on before you have completed the procedure. If the calculator still does not turn on, please contact Customer Support for further information.

1. Press and hold the ON key for 10 seconds.
2. Press and hold the ON key and the third menu key simultaneously. Release the third menu key, then release the ON key.
3. Press and hold the ON key, the first menu key, and the sixth menu key simultaneously. Release the sixth menu key, then release the first menu key, and then release the ON key.
4. Locate the small hole in the back of the calculator. Insert the end of a straightened metal paper clip into the hole as far as it will go. Hold it there for 1 second, then remove it. Press the ON key.
5. Remove the batteries (see “Batteries” on page R-7), press and hold the ON key for 10 seconds, and then put the batteries back in. Press the ON key.

Glossary

aplet	A small application, limited to one topic. The built-in aplet types are Function, Parametric, Polar, Sequence, Solve, and Statistics. An aplet can be filled with the data and solutions for a specific problem. It is reusable (like a program, but easier to use) and it records all your settings and definitions.
command	An operation for use in programs. Commands can store results in variables, but do not display results. Arguments are separated by semi-colons, such as `DISP` *expression*`;`*line#*.
expression	A number, variable, or algebraic expression (numbers plus functions) that produces a value.
function	An operation, possibly with arguments, that returns a result. It does not store results in variables. The arguments must be enclosed in parentheses and separated with commas (or periods in Comma mode), such as `CROSS`(*matrix1,matrix2*).
HOME	The basic starting point of the calculator. Go to HOME to do calculations.
Library	For aplet management: to start, save, reset, send and receive aplets.
list	A set of values separated by commas (periods if the Decimal Mark is Comma) and enclosed in braces. Lists are commonly used to enter statistical data and to evaluate a function with multiple values. Created and manipulated by the List editor and catalog.
matrix	A two-dimensional array of values separated by commas (periods if the Decimal Mark is Comma) and enclosed in nested brackets. Created and manipulated by the Matrix catalog and editor. Vectors are also handled by the Matrix catalog and editor.

menu	A choice of options given in the display. It can appear as a list or as a set of *menu-key labels* across the bottom of the display.
menu keys	The top row of keys. Their operations depend on the current context. The labels along the bottom of the display show the current meanings.
note	Text that you write in the Notepad or in the Note view for a specific aplet.
program	A reusable set of instructions that you record using the Program editor.
sketch	A drawing that you make in the Sketch view for a specific aplet.
variable	The name of a number, list, matrix, note, or graphic that is stored in memory. Use STO▸ to store and use VARS to retrieve.
vector	A one-dimensional array of values separated by commas (periods if the Decimal Mark is Comma) and enclosed in single brackets. Created and manipulated by the Matrix catalog and editor.
views	The possible contexts for an aplet: Plot, Plot Setup, Numeric, Numeric Setup, Symbolic, Symbolic Setup, Sketch, Note, and special views like split screens.

Operating details

Operating temperature: 0° to 45°C (32° to 113°F).

Storage temperature: –20° to 65°C (–4° to 149°F).

Operating and storage humidity: 90% relative humidity at 40°C (104°F) maximum. *Avoid getting the calculator wet.*

Battery operates at 4.5V dc, 60mA maximum.

Batteries

When battery power is low, the **((•))** annunciator stays on, even when the calculator is off. There is also a warning message that appears when the calculator is on: `Warning: Low Bat`.

The HP 39G/40G uses three AAA batteries. *Be sure all three are of the same brand and type.* Rechargeable batteries are *not* recommended because of their lower capacity and more sudden demise.

To replace batteries:

1. Turn the calculator off and place the slide cover over the keyboard to prevent keys from being pressed.

CAUTION Your calculator can lose memory if it is turned on while the batteries are being removed.
Under no circumstances should the batteries be deliberately inserted backwards and the calculator turned on. This may cause hardware damage and will void the warranty.

2. Remove the battery compartment door from the rear of the calculator by pressing down on the dimple and pushing the door off.
3. Replace the batteries within 2 minutes to avoid memory loss. Position the fresh batteries according to the diagram inside the battery compartment.

The Netherlands

This regulation applies only to The Netherlands.

Batteries are delivered with this product. When empty do not throw them away but collect as small chemical waste.

Bij dit produkt zijn batterijen geleverd. Wanneer deze leeg zijn, moet u ze niet weggoolen maar inlevern als KCA.

Menu maps of the VARS menu

Home variables

The home variables are:

Category	Available name
Complex	`Z1`...`Z9`, `Z0`

Category	Available name (Continued)
Graphic	G1…G9, G0
Library	Function Parametric Polar Sequence Solve Statistics *User-named*
List	L1…L9, L0
Matrix	M1…M9, M0
Modes	Ans Date HAngle HDigits HFormat Ierr Time
Notepad	*User-named*
Program	Editline *User-named*
Real	A...Z, θ

Function aplet variables

The function aplet variables are:

Category	Available name	
Plot	Axes Connect Coord FastRes Grid Indep InvCross Labels Recenter Simult Tracing	Xcross Ycross Xtick Ytick Xmin Xmax Ymin Ymax Xzoom Yxoom

Category	Available name (Continued)	
Plot-FCN	Area Extremum Isect	Root Slope
Symbolic	Angle F1 F2 F3 F4 F5	F6 F7 F8 F9 F0
Numeric	Digits Format NumCol NumFont NumIndep	NumRow NumStart NumStep NumType NumZoom
Note	NoteText	
Sketch	Page	PageNum

Parametric aplet variables

The parametric aplet variables are:

Category	Available name	
Plot	Axes Connect Coord Grid Indep InvCross Labels Recenter Simult Tmin Tmax	Tracing Tstep Xcross Ycross Xtick Ytick Xmin Xmax Ymin Ymax Xzoom Yzoom

Category	Available name (Continued)	
Symbolic	Angle	Y5
	X1	X6
	Y1	Y6
	X2	X7
	Y2	Y7
	X3	X8
	Y3	Y8
	X4	X9
	Y4	Y9
	X5	X0
		Y0
Numeric	Digits	NumRow
	Format	NumStart
	NumCol	NumStep
	NumFont	NumType
	NumIndep	NumZoom
Note	NoteText	
Sketch	Page	PageNum

Polar aplet variables

The polar aplet variables are:

Category	Available names	
	Axes	
	Connect	Xcross
	Coord	Ycross
	Grid	Xtick
	Indep	Ytick
	InvCross	Xmin
	Labels	Xmax
	Recenter	Ymin
	Simult	Ymax
	Umin	Xzoom
	Umax	Yxoom
	θstep	
	Tracing	
Symbolic	Angle	R6
	R1	R7
	R2	R8
	R3	R9
	R4	R0
	R5	

Category	Available names (Continued)	
Numeric	Digits Format NumCol NumFont NumIndep	NumRow NumStart NumStep NumType NumZoom
Note	NoteText	
Sketch	Page	PageNum

Sequence aplet variables

The sequence aplet variables are:

Category	Available name	
Plot	Axes Coord Grid Indep InvCross Labels Nmin Nmax Recenter SeqPlot Simult	Tracing Xcross Ycross Xtick Ytick Xmin Xmax Ymin Ymax Xzoom Yzoom
Symbolic	Angle U1 U2 U3 U4 U5	U6 U7 U8 U9 U0
Numeric	Digits Format NumCol NumFont NumIndep	NumRow NumStart NumStep NumType NumZoom
Note	NoteText	
Sketch	Page	PageNum

Solve aplet variables

The solve aplet variables are:

Category	Available name	
Plot	Axes Connect Coord FastRes Grid Indep InvCross Labels Recenter Tracing	Xcross Ycross Xtick Ytick Xmin Xmax Ymin Ymax Xzoom Yxoom
Symbolic	Angle E1 E2 E3 E4 E5	E6 E7 E8 E9 E0
Numeric	Digits Format	NumCol NumRow
Note	NoteText	
Sketch	Page	PageNum

Statistics aplet variables

The statistics aplet variables are:

Category	Available name	
Plot	Axes Connect Coord Grid Hmin Hmax Hwidth Indep InvCross Labels Recenter S1mark S2mark S3mark	S4mark S5mark StatPlot Tracing Xcross Ycross Xtick Ytick Xmin Xmax Ymin Ymax Xzoom Yxoom
Symbolic	Angle S1fit S2fit	S3fit S4fit S5fit
Numeric	C0,...C9 Digits Format NumCol	NumFont NumRow StatMode
Stat-One	MaxΣ MeanΣ Median MinΣ NΣ Q1	Q3 PSDev SSDev PVarΣ SVarΣ TotΣ
Stat-Two	Corr Cov Fit MeanX MeanY RelErr	ΣX ΣX2 ΣXY ΣY ΣY2
Note	NoteText	
Sketch	Page	PageNum

Menu maps of the MATH menu

Math functions

The math functions are:

Category	Available name	
Calculus	∂ ∫ TAYLOR	
Complex	ARG CONJ	IM RE
Constant	e i	MAXREAL MINREAL π
Hyperb.	ACOSH ASINH ATANH COSH SINH	TANH ALOG EXP EXPM1 LNP1
List	CONCAT ΔLIST MAKELIST πLIST POS	REVERSE SIZE ΣLIST SORT
Loop	ITERATE RECURSE Σ	
Matrix	COLNORM COND CROSS DET DOT EIGENVAL EIGENVV IDENMAT INVERSE LQ LSQ LU MAKEMAT	QR RANK ROWNORM RREF SCHUR SIZE SPECNORM SPECRAD SVD SVL TRACE TRN

Category	Available name (Continued)	
Polynom.	POLYCOEF	POLYFORM
	POLYEVAL	POLYROOT
Prob.	COMB	UTPC
	!	UTPF
	PERM	UTPN
	RANDOM	UTPT
Real	CEILING	MIN
	DEG→RAD	MOD
	FLOOR	%
	FNROOT	%CHANGE
	FRAC	%TOTAL
	HMS→	RAD→DEG
	→HMS	ROUND
	INT	SIGN
	MANT	TRUNCATE
	MAX	XPON
Stat-Two	PREDX	
	PREDY	
Symbolic	=	QUAD
	ISOLATE	QUOTE
	LINEAR?	|
Tests	<	AND
	≤	IFTE
	==	NOT
	≠	OR
	>	XOR
	≥	
Trig	ACOT	COT
	ACSC	CSC
	ASEC	SEC

Program constants

The program constants are:

Category	Available name	
Angle	Degrees Grads Radians	
Format	Standard Fixed	Sci Eng Fraction
SeqPlot	Cobweb Stairstep	
S1...5fit	Linear LogFit ExpFit Power	QuadFit Cubic Logist User
StatMode	Stat1Var Stat2Var	
StatPlot	Hist BoxW	

Program commands

The program commands are:

Category	Command	
Aplet	CHECK SELECT SETVIEWS UNCHECK	
Branch	IF THEN ELSE END	CASE IFERR RUN STOP
Drawing	ARC BOX ERASE FREEZE	LINE PIXOFF PIXON TLINE
Graphic	DISPLAYR RDISPLAY RGROB GROBNOT GROBOR GROBXOR	MAKEGROB PLOTR RPLOT REPLACE SUB ZEROGROB
Loop	FOR = TO STEP END DO	UNTIL END WHILE REPEAT END BREAK
Matrix	ADDCOL ADDROW DELCOL DELROW EDITMAT RANDMAT	REDIM REPLACE SCALE SCALEADD SUB SWAPCOL SWAPROW
Print	PRDISPLAY PRHISTORY PRVAR	
Prompt	BEEP CHOOSE DISP DISPTIME EDITMAT FREEZE	GETKEY INPUT MSGBOX PROMPT WAIT
Stat-One	DO1VSTATS RANDSEED	SETFREQ SETSAMPLE
Stat-Two	DO2VSTATS SETDEPEND SETINDEP	

Selected status messages

The status messages are:

Message	Meaning
Bad Argument Type	Incorrect input for this operation.
Bad Argument Value	The value is out of range for this operation.
Infinite Result	Math exception, such as 1/0.
Insufficient Memory	You must recover some memory to continue operation. Delete one or more matrices, lists, notes, or programs (using catalogs), or custom (not built-in) aplets (using SHIFT *MEMORY*).
Insufficient Statistics Data	Not enough data points for the calculation. For two-variable statistics there must be two columns of data, and each column must have at least four numbers.
Invalid Dimension	Array argument had wrong dimensions.
Invalid Statistics Data	Need two columns with equal numbers of data values.
Invalid Syntax	The function or command you entered does not include the proper arguments or order of arguments. The delimiters (parentheses, commas, periods, and semi-colons) must also be correct. Look up the function name in the index to find its proper syntax.
Name Conflict	The | (where) function attempted to assign a value to the variable of integration or summation index.
No Equations Checked	You must enter and check an equation (Symbolic view) before evaluating this function.

Message	**Meaning (Continued)**
(OFF SCREEN)	Function value, root, extremum, or intersection is not visible in the current screen.
Receive Error	Problem with data reception from another calculator. Re-send the data.
Too Few Arguments	The command requires more arguments than you supplied.
Undefined Name	The global variable named does not exist.
Undefined Result	The calculation has a mathematically undefined result (such as 0/0).
Out of Memory	You must recover a lot of memory to continue operation. Delete one or more matrices, lists, notes, or programs (using catalogs), or custom (not built-in) aplets (using SHIFT *MEMORY*).

Index

E

F

G

H

M

N

O

P

S

T

U