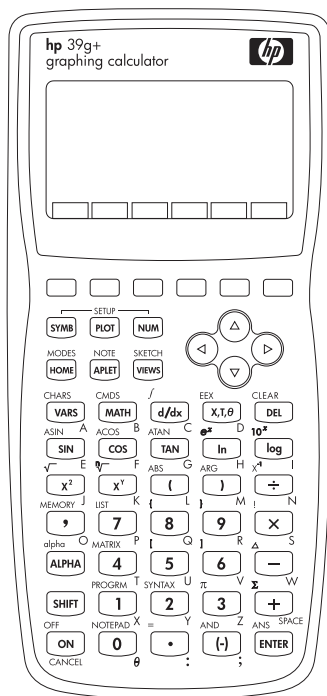


# hp 39g+

## graphing calculator

# user's guide

Version 1.2



invent



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# Preface

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

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

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

**<http://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:

`MODE`, `ENTER`, `ON`.

- 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 merchantability 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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The programs that control your hp 39g+ are copyrighted and all rights are reserved. Reproduction, adaptation, or translation of those programs without prior written permission from Hewlett-Packard Company is also prohibited.

# 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 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

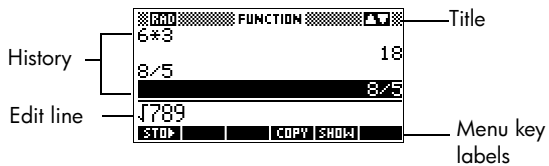
## To adjust the contrast

Simultaneously press  $\boxed{\text{ON}}$  and  $\boxed{+}$  (or  $\boxed{-}$ ) to increase (or decrease) the contrast.

## To clear the display

- Press *CANCEL* to clear the edit line.
- Press  $\boxed{\text{SHIFT}}$  *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.  $\boxed{\text{STO}}$  is the label for the first menu key in this picture. "Press  $\boxed{\text{STO}}$ " 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 ( $\boxed{\text{HOME}}$ ) 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  $\blacktriangledown$  and  $\blacktriangle$  symbols indicate whether there is more history in the HOME display. Press the  $\blacktriangledown$  and  $\blacktriangle$  to scroll in the HOME display.

## NOTE

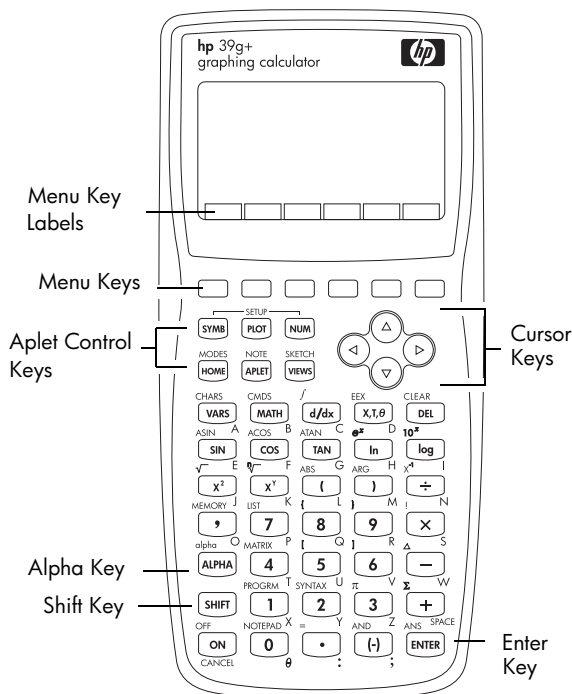
This user's guide contains images from the hp 39g+ and do not display the  $\boxed{\text{STO}}$  menu key label.

**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 <b>SHIFT</b> again.
$\alpha$	Alpha in effect for next keystroke. To cancel, press <b>ALPHA</b> 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
	Displays the Symbolic view for the current aplet. See “Symbolic view” on page 1-16.
	Displays the Plot view for the current aplet. See “Plot view” on page 1-17.
	Displays the Numeric view for the current aplet. See “Numeric view” on page 1-17.
	Displays the HOME view. See “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 . All mathematical functions are available in the HOME. The name of the current aplet is displayed in the title of the home view.” on page 1-1.
	Displays the Aplet Library menu. See “Aplet library” on page 1-16.
	Displays the VIEWS menu. See “Aplet views” on page 1-16.

## Entry/Edit keys

The entry and edit keys are:

Key	Meaning
 (CANCEL)	Cancels the current operation if the calculator is on by pressing  . Pressing  , then OFF turns the calculator off.
	Accesses the function printed in blue above a key.
	Returns to the HOME view, for performing calculations.
	Accesses the alphabetical characters printed in orange below a key. Hold down to enter a string of characters.
	Enters an input or executes an operation. In calculations,  acts like “=”. When  or  is present as a menu key,  acts the same as pressing  or  .
	Enters a negative number. To enter -25, press  25. <i>Note: this is not the same operation that the subtract button performs ().</i>
	Enters the independent variable by inserting X, T, θ, or N into the edit line, depending on the current active aplet.
	Deletes the character under the cursor. Acts as a backspace key if the cursor is at the end of the line.
 CLEAR	Clears all data on the screen. On a settings screen, for example Plot Setup,  CLEAR returns all settings to their default values.
 ,  ,  ,	Moves the cursor around the display. Press  first to move to the beginning, end, top or bottom.
	

Key	Meaning (Continued)
<b>SHIFT</b> <i>CHARS</i>	Displays a menu of all available characters. To type one, use the arrow keys to highlight it, and press <b>OK</b> . To select multiple characters, select each and press <b>ENTER</b> , then press <b>OK</b> .

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



## HELPMITH

The hp 39g+ built-in help is available in HOME only. It provides syntax help for built-in math functions.

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

### Example

Press **[SHIFT]** **SYNTAX**

**[X<sup>2</sup>]** **[ENTER]**



*Note: Remove the left parenthesis from built-in functions such as sine, cosine, and tangent before invoking the HELPMITH 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 **MATH** takes you to the beginning of the MATH menu.

See “Math functions by category” on page 11-2 for details of the math functions.

**HINT**

When using the MATH menu, or any menu on the hp 39g+, 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 16-13.

**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 **ENTER** (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 **ENTER** or **ENTER** when you have highlighted your selection.
- To speed-search a list, type the first letter of the word. For example, to find the Matrix category in **MATH**, press **M**, 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 **CANCEL**. 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 (**EDIT**). Some input forms include items to check (**CHK**). See below for examples input forms.



### Reset input form values

To reset a field to its default values 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: <b>Degrees.</b> 360 degrees in a circle. <b>Radians.</b> $2\pi$ radians in a circle. <b>Grads.</b> 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	<p>The number format mode you set is the number format used in both HOME and the current aplet.</p> <p><b>Standard.</b> Full-precision display.</p> <p><b>Fixed.</b> Displays results rounded to a number of decimal places. Example: 123.456789 becomes 123.46 in Fixed 2 format.</p> <p><b>Scientific.</b> 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.</p> <p><b>Engineering.</b> 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.</p> <p><b>Fraction.</b> 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 1-25.</p>
Decimal Mark	<p><b>Dot</b> or <b>Comma.</b> 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.</p>

## Setting a mode

This example demonstrates how to change the angle measure from the default mode, radians, to degrees for the current applet. 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 **[CHOOSE]** 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 **[CHOOSE]**.

## Aplets (E-lessons)

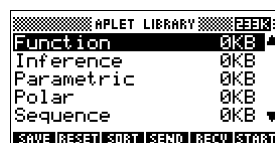
Aplets are the application environments where you explore different classes of mathematical operations. You select the applet that you want to work with.

Aplets come from a variety of sources:

- Built-in the hp 39g+ (initial purchase).
- Aplets created by saving existing applets, which have been modified, with specific configurations. See “Creating new applets based on existing applets” on page 17-1.
- Downloaded from HP’s Calculators web site.

- Copied from another calculator.

Aplets are stored in the Aplet library. See “Aplet library” on page 1-16 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 1-18 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 $\theta$ . 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+ is supplied with two teaching aplets: Quad Explorer and Trig Explorer. You cannot modify configuration settings for these aplets.

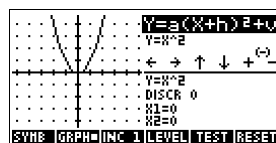
A great many more teaching applets can be found at HP's web site and other web sites created by educators, together with accompanying documentation, often with student work sheets. These can be downloaded free of charge and transferred to the hp 39g+ using the separately supplied Connectivity Kit.

## Quad Explorer applet

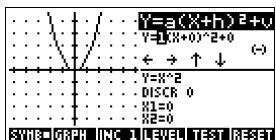
The **Quad Explorer** applet is used to investigate the behaviour of  $y = a(x+h)^2 + v$  as the values of  $a$ ,  $h$  and  $v$  change, both by manipulating the equation and seeing the change in the graph, *and* by manipulating the graph and seeing the change in the equation.

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

Press **APLET**, select Quad Explorer, and then press **EDIT**. The Quad Explorer applet opens in **EDIT** 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 **EDIT** displays a sub-expression of your equation.



Pressing the **▶** and **◀** key moves between sub-expressions, while pressing the **▲** and **▼** key changes their values.

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



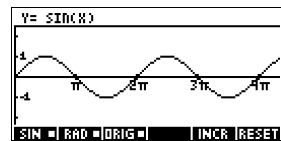
A **TEST** button is provided to evaluate the student's knowledge. Pressing **TEST** displays a target quadratic graph. The student must manipulate the equation's parameters to make the equation match the target graph. When a student feels that they have correctly chosen the parameters a **CHECK** button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



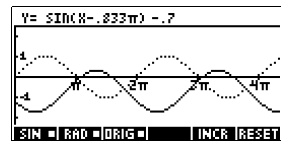
## Trig Explorer applet

The **Trig Explorer** applet 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.

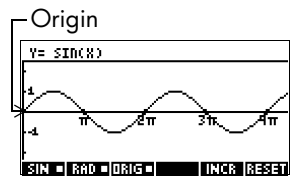
Press **APLET**, select Trig Explorer, and then press **START** to display the screen shown right.



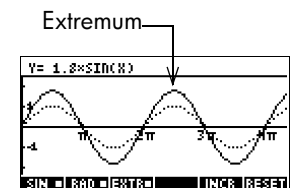
In this mode, the graph controls the equation. Pressing the **▲** **▼** and **◀** **▶** keys transforms the graph, with these transformations reflected in the equation.



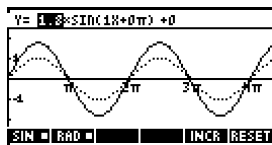
The button labelled **ORIG** is a toggle between **ORIG** and **EXTR**. When **ORIG** is chosen, the 'point of control' is at the origin (0,0) and the **▲** **▼** and **◀** **▶** keys control vertical and horizontal transformations. When **EXTR** is chosen the 'point of control' is on the first extremum 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 controlled by 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 applet 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 applet

Press **[APLET]** to display the Aplet library menu. Select the applet and press **[F10]** or **[ENTER]**.

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

## Aplet views

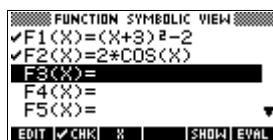
When you have configured an applet to define the relation or data that you want to explore, you can display it in different views. Here are illustrations of the three major applet views (Symbolic, Plot, and Numeric), the six supporting applet views (from the VIEWS menu), and the two user-defined views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

### Symbolic view

Press **[SYMB]** to display the applet'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.

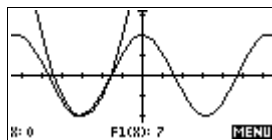


## Plot view

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 2-16 for further information.

X	F1	F2
0	2	2
1	2.61	1.440000
2	8.84	1.460133
3	8.84	1.410673
4	9.56	1.842122
5	10.25	1.755165

0

ZOOM1 | BIG | DEFN |

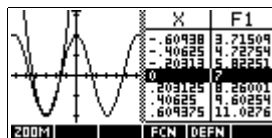
## Plot-Table view

The VIEWS menu contains the Plot-Table view.

**[VIEWS]**

Select Plot-Table **[F12]**

Splits the screen into the plot and the data table. See "Other views for scaling and splitting the graph" on page 2-14 for further information.



## Plot-Detail view

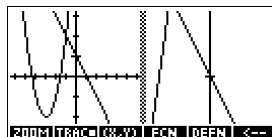
The VIEWS menu contains the Plot-Detail view.

**[VIEWS]**

Select Plot-Detail **[F12]**

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

See "Other views for scaling and splitting the graph" on page 2-14 for further information.



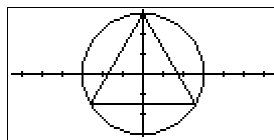
## Overlay Plot view

The VIEWS menu contains the Overlay Plot view.

**VIEWS**

Select Overlay Plot **018**

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



See “Other views for scaling and splitting the graph” on page 2-14 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.



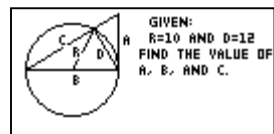
See “Notes and sketches” on page 15-1 for further information.

## Sketch view

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

Displays pictures to supplement an aplet.

See “Notes and sketches” on page 15-1 for further information.

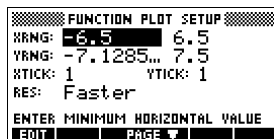


## Aplet view configuration

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.

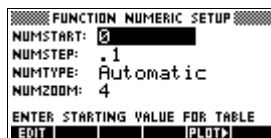
## Plot Setup

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



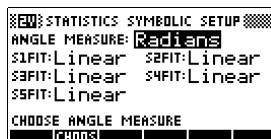
## Numeric Setup

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 **EDIT** 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+ calculators. See “Sending and receiving aplets” on page 17-4.

## 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 16-13 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+ 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 (X<sup>2</sup>)  
 (-) 14  
 (X) (SHIFT) (√) 8 ( )  
 (÷) (-) 3  
 (ln) 45 ( )  
 (ENTER)

FUNCTION  
 (23^2-14\*sqrt(8))/-3\*LN(45)  
 -620.996104305  
 STO

## 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  $5 \times 10^4$  or  $3.21 \times 10^{-7}$  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<sup>Y</sup>)**.)

## 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

FUNCTION  
 (4E-13)\*(6E23)/3E-5  
 STO

(ENTER)

FUNCTION  
 4.E-13\*6.E23/.00003  
 8.E15  
 STO

## 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  $\text{SIN}(45)$ . 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+ calculates according to the order of *algebraic precedence* (the next topic). Following are some examples using parentheses.

Entering...	Calculates...
$\boxed{\text{SIN}} \ 45 \boxed{+} \boxed{\text{SHIFT}} \ \pi$	$\sin(45 + \pi)$
$\boxed{\text{SIN}} \ 45 \boxed{)} \boxed{+} \boxed{\text{SHIFT}} \ \pi$	$\sin(45) + \pi$
$\boxed{\text{SHIFT}} \ \sqrt{\phantom{x}} \ 85 \boxed{\times} \ 9$	$\sqrt{85} \times 9$
$\boxed{\text{SHIFT}} \ \sqrt{\phantom{x}} \ (\ 85 \boxed{\times} \ 9 \ )$	$\sqrt{85 \times 9}$

## 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

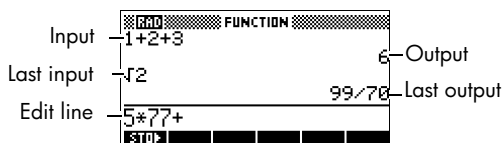
The smallest number the hp 39g+ can represent is  $1 \times 10^{-499}$  (1E-499). A smaller result is displayed as zero. The largest number is  $9.99999999999 \times 10^{499}$  (1E499). A greater result is displayed as this number.

## 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  $\uparrow$ ), the **COPY** and **SHOW** menu labels appear.



### To copy a previous line

Highlight the line (press  $\uparrow$ ) 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  $\uparrow$ ) 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 **+**, **-**, **×**, 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 1-22 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  $\theta$ . See Chapter 12, "Variables and memory management" for more information on variables. For example:

1. Perform a calculation.

45 **+** 8 **X<sup>Y</sup>** 3  
**ENTER**



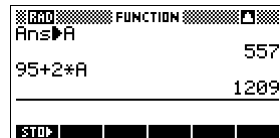
2. Store the result in the A variable.

**SHIFT** **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.
	Copies the highlighted expression to the position of the cursor in the edit line.
	Displays the current expression in standard mathematical form.
	Deletes the highlighted expression from the display history, unless there is a cursor in the edit line.
 <i>CLEAR</i>	Clears all lines of display history and the edit line.

## Clearing the display history

It's a good habit to clear the display history ( *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.

 *MODES*



2. Select Number Format, press **CHOOSE** to display the options, and highlight Fraction.



3. Press **OK** to select the Number Format option, then move to the precision value field.



4. Enter the precision value 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+ 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:



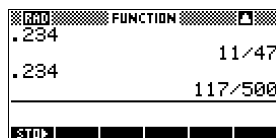
- Precision set to 2:



- Precision set to 3:



- Precision set to 4:



## Fraction calculations

When entering fractions:

- You use the  $\frac{\square}{\square}$  key to separate the numerator part and the denominator part of the fraction.
- To enter a mixed fraction, for example,  $1\frac{1}{2}$ , you enter it in the format  $(1+\frac{1}{2})$ .

For example, to perform the following calculation:

$$3(2^3/4 + 5^7/8)$$

1. Set the Number format mode to Fraction and specify a precision value of 4. *Select Fraction*

**SHIFT** MODES  $\nabla$

**CHOOS** Select

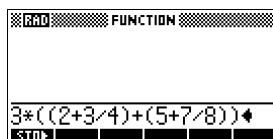
Fraction

**ENTER**  $\blacktriangleright$  4  $\frac{\square}{\square}$



- Enter the calculation.

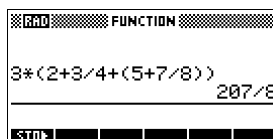
$3 \times ( ( 2 + 3 ) \div 4 ) + ( 5 + 7 ) \div 8$



*Note: Ensure you are in the HOME view.*

- Evaluate the calculation.

**ENTER**



## Converting decimals to fractions

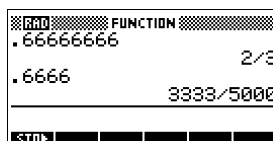
To convert a decimal value to a fraction:

- Set the number format mode to **Fraction**.
- Either retrieve the value from the History, or enter the value on the command line.
- Press **ENTER** to convert the number to a fraction.

When converting a decimal 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+ 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**  
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+ 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 ( <b>A</b> PLET)	Aplets.
Sketch editor ( <b>S</b> HIFT SKETCH)	Sketches and diagrams, See Chapter 15, "Notes and sketches".
List ( <b>L</b> IST)	Lists. In HOME, lists are enclosed in {}. See Chapter 14, "Lists".
Matrix ( <b>M</b> ATRIX)	One- and two-dimensional arrays. In HOME, arrays are enclosed in []. See Chapter 13, "Matrices".
Notepad ( <b>N</b> OTEPAD)	Notes (short text entries). See Chapter 15, "Notes and sketches".
Program ( <b>P</b> ROGRAM)	Programs that you create, or associated with user-defined aplets. See Chapter 16, "Programming".



# Aplets and their views

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## 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 applet. You can graph any of the relations (in the same applet) simultaneously by selecting them.

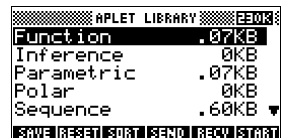
## Defining an expression (Symbolic view)

Choose the applet from the Aplet Library.



APLET


Press  or  to select an applet.

START

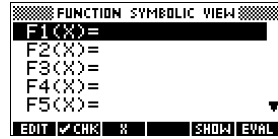


The Function, Parametric, Polar, and Sequence aplets start in the Symbolic view.

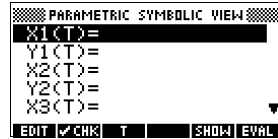
If the highlight is on an existing expression, scroll to an empty line—unless you don't mind writing over the expression—or, clear one line () or all lines ().

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

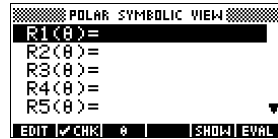
- **For a Function definition**, enter an expression to define  $F(X)$ . The only independent variable in the expression is  $X$ .



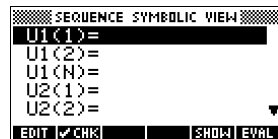
- **For a Parametric definition**, enter a pair of expressions to define  $X(T)$  and  $Y(T)$ . The only independent variable in the expressions is  $T$ .



- **For a Polar definition**, enter an expression to define  $R(\theta)$ . The only independent variable in the expression is  $\theta$ .



- **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.

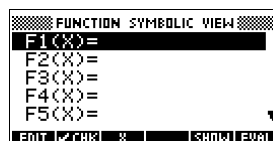
# Evaluating expressions

## In applets

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 **EURL**. If a function calls another function, then **EURL** resolves all references to other functions in terms of their independent variable.

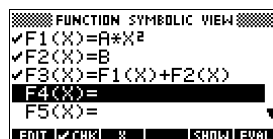
1. Choose the Function applet.

APLET  
Select Function  
START

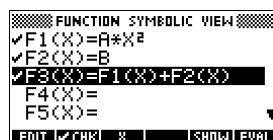


2. Enter the expressions in the Function applet's Symbolic view.

ALPHA A    
 $x^2$    
ALPHA B   
ALPHA F1     
 +  
ALPHA F2

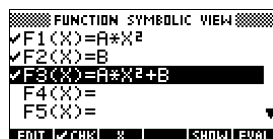


3. Highlight F3(X).



4. Press **EURL**

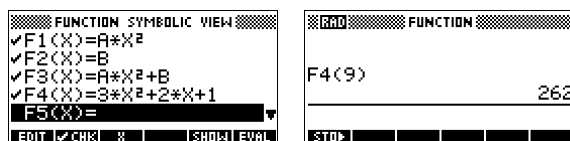
Note how the values for F1(X) and F2(X) are substituted into F3(X).



## 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
<b>EDIT</b>	Copies the highlighted expression to the edit line for editing. Press <b>OK</b> when done.
<b>✓CHK</b>	Checks/unchecks the current expression (or set of expressions). Only checked expression(s) are evaluated in the Plot and Numeric views.
<b>X</b>	Enters the independent variable in the Function applet. Or, you can use the <b>(X,T,θ)</b> key on the keyboard.
<b>T</b>	Enters the independent variable in the Parametric applet. Or, you can use the <b>(X,T,θ)</b> key on the keyboard.
<b>θ</b>	Enters the independent variable in the Polar applet. Or, you can use the <b>(X,T,θ)</b> key on the keyboard.
<b>M</b>	Enters the independent variable in the Sequence applet. Or, you can use the <b>(X,T,θ)</b> key on the keyboard.
<b>SHOW</b>	Displays the current expression in text book form.
<b>EVAL</b>	Resolves all references to other definitions in terms of variables and evaluates all arithmetic expressions.
<b>(VARS)</b>	Displays a menu for entering variable names or contents of variables.

Key	Meaning (Continued)
<b>MATH</b>	Displays the menu for entering math operations.
<b>SHIFT</b> CHARS	Displays special characters. To enter one, place the cursor on it and press <b>OK</b> . To remain in the CHARS menu and enter another special character, press <b>ECHO</b> .
<b>DEL</b>	Deletes the highlighted expression or the current character in the edit line.
<b>SHIFT</b> 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.

- 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.
- Press **PAGE** to view more settings.
- 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 ( $\theta$ ) value range for the graph.
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 **PRG** 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.

Field	Meaning (Continued)
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
<b>SHIFT CLEAR</b>	Erases the plot and axes.
<b>VIEWS</b>	Offers additional pre-defined views for splitting the screen and for scaling ("zooming") the axes.
<b>SHIFT</b> 	Moves cursor to far left or far right.
<b>SHIFT</b> 	
	Moves cursor between relations.
	
<b>PAUSE</b> or <b>ON</b>	Interrupts plotting.
<b>CONT</b>	Continues plotting if interrupted.

Key	Meaning (Continued)
<b>MENU</b>	Turns menu-key labels on and off. When the labels are off, pressing <b>MENU</b> turns them back on. <ul style="list-style-type: none"> <li>Pressing <b>MENU</b> once displays the full row of labels.</li> <li>Pressing <b>MENU</b> a second time removes the row of labels to display only the graph.</li> <li>Pressing <b>MENU</b> a third time displays the coordinate mode.</li> </ul>
<b>ZOOM</b>	Displays the ZOOM menu list.
<b>TRACE</b>	Turns trace mode on/off. A white box appears over the <b>E</b> on <b>TRACE</b> .
<b>GOTO</b>	Opens an input form for you to enter an $X$ (or $T$ or $N$ or $\theta$ ) value. Enter the value and press <b>OK</b> . The cursor jumps to the point on the graph that you entered.
<b>FCN</b>	Function applet only: turns on menu list for root-finding functions (see "Analyse graph with FCN functions" on page 3-4).
<b>DEFM</b>	Displays the current, <i>defining</i> expression. Press <b>MENU</b> 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 **GO TO** menu key. Press **GO TO**, 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.

The **Set Factors...** option enables you to set the factors by which you zoom in or zoom out, 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 <i>without</i> changing the scale.
Box...	Lets you draw a box to zoom in on. See "Other views for scaling and splitting the graph" on page 2-14.
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 <b>Set Factors...</b> )
Out	Multiplies horizontal and vertical scales by the X-factor and Y-factor (see <b>Set Factors...</b> ).
X-Zoom In	Divides horizontal scale only, using X-factor.
X-Zoom Out	Multiplies horizontal scale, using X-factor.

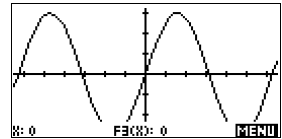
<b>Option</b>	<b>Meaning (Continued)</b>
Y-Zoom In	Divides vertical scale only, using Y-factor.
Y-Zoom Out	Multiplies vertical scale only, using Y-factor.
Square	Changes the vertical scale to match the horizontal scale. (Use this after doing a Box Zoom, X-Zoom, or Y-Zoom.)
Set Factors...	Sets the X-Zoom and Y-Zoom factors for zooming in or zooming out. 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 applets, 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 applets.)
Integer	Rescales horizontal axis only, making each pixel = 1 unit. (Not available in Sequence or Statistics applets.)
Trig	Rescales horizontal axis so 1 pixel = $\pi/24$ radians, 7.58, or $8\frac{1}{3}$ grads; rescales vertical axis so 1 pixel = 0.1 unit. (Not in Sequence or Statistics applets.)

Option	Meaning (Continued)
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

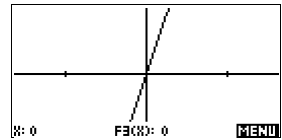
The following screens show the effects of zooming options on a plot of  $3 \sin x$ .

Plot of  $3 \sin x$




**Zoom In:**

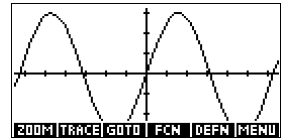
**MENU** **ZOOM** In **OK**



**Un-zoom:**

**ZOOM** Un-zoom **OK**

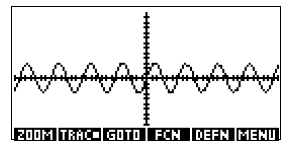
Note: Press  to move to the bottom of the Zoom list.



**Zoom Out:**

**ZOOM** Out **OK**

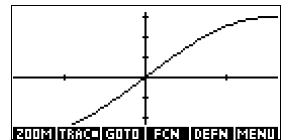
Now un-zoom.



**X-Zoom In:**

**ZOOM** X-Zoom In **OK**

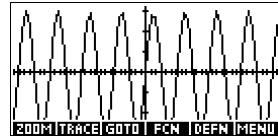
Now un-zoom.



### X-Zoom Out:

**ZOOM** X-Zoom Out **OK**

Now un-zoom.



### Y-Zoom In:

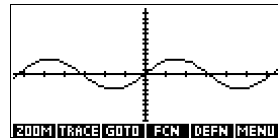
**ZOOM** Y-Zoom In **OK**

Now un-zoom.



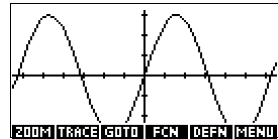
### Y-Zoom Out:

**ZOOM** Y-Zoom Out **OK**



### Zoom Square:

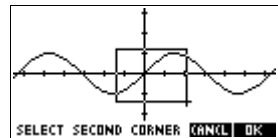
**ZOOM** Square **OK**



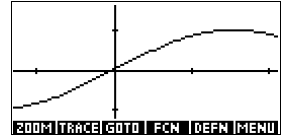
## To box zoom

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 **08** 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 **08**.
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 applets, for example those that you download from the world wide web, the preset viewing options menu can also contain options that relate to the applet.

### 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) <i>without</i> 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 applets, 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 applets.)
Integer	Rescales horizontal axis only, making each pixel=1 unit. (Not available in Sequence or Statistics applets.)

Option	Meaning (Continued)
Trig	Rescales horizontal axis so 1 pixel = $\pi/24$ radian, 7.58, or $8^{1/3}$ grads; rescales vertical axis so 1 pixel = 0.1 unit. (Not in Sequence or Statistics aplets.)

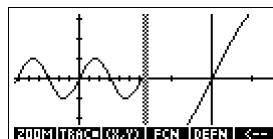
## Split the screen

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

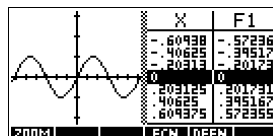
**[ENTER]**. This zooms the right side. Here is an example of split screen with Zoom In.









- 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.



- 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.
- To move between functions, use the  and  cursor keys to move the cursor from one graph to another.
- To return to a full Numeric (or Plot) view, press  (or ).

## Overlay plots

If you want to plot over an existing plot *without erasing* that plot, then use  Overlay Plot instead of . 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  $1 \times 1$  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  $\pi$ .

## About the numeric view

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

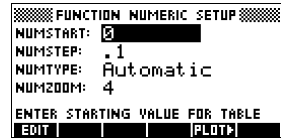
X	F1	F2	
0	1	2	
.1	.9	2.61	
.2	.98	8.84	
.4	.6	9.56	
.5	.5	10.25	



# 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.



- 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 **[CHOOSE]**, 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.
- 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
<b>ZOOM</b>	Displays ZOOM menu list.
<b>BIG</b>	Toggles between two character sizes.
<b>DEFN</b>	Displays the <i>defining</i> function expression for the highlighted column. To cancel this display, press <b>DEF</b> .

### 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.)

Option	Meaning (Continued)
Trig	Changes intervals for independent variable to $\pi/24$ radian or 7.5 degrees or $8\frac{1}{3}$ 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.

X	F1		
.075	.0249292		
.1	.0998334		
.125	.1246747		
.15	.1444881		
.175	.1741081		
.2	.1986693		
9.98334166468E-2			
ZOOM		BIG	DEFN

X	F1		
0	0		
.1	.0998334		
.2	.1986693		
.3	.2955208		
.4	.3894188		
.5	.4794255		
9.98334166468E-2			
ZOOM		BIG	DEFN

## 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,  $\theta$ , 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**.

You enter numbers into the X column

X	F1	F2
-2	3	-1
3.7	-2.7	42.89
100	-99	106807
6	-5	79

F1 and F2 entries are generated automatically

**EDIT INS SORT BIG DEFN**

## Clear data

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

## “Build Your Own” menu keys

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

## Example: plotting a circle

Plot the circle,  $x^2 + y^2 = 9$ . First rearrange it to read

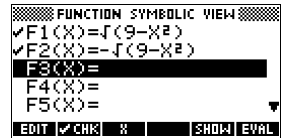
$$y = \pm\sqrt{9-x^2}.$$

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

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

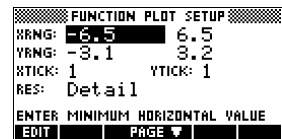
1. In the Function applet, specify the functions.

*Select*  
 Function   
   9  
     
  
    9

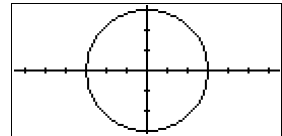


2. Reset the graph setup to the default settings.

*SETUP-PLOT*  
 *CLEAR*

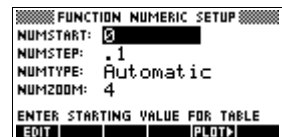


3. Plot the two functions and hide the menu so that you can see all the circle.



4. Reset the numeric setup to the default settings.

*SETUP-NUM*  
 *CLEAR*



5. Display the functions in numeric form.

NUM

X	F1	F2	
0			
.1	.998333	-.2	.998333
.2	.993326	-.2	.993333
.3	.984622	-.2	.98446
.4	.973214	-.2	.97321
.5	.95804	-.2	.95804
0			
ROOM		BIG	DEFN

# Function applet

---

## About the Function applet

The Function applet 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 applet by stepping you through an example. See “Applet views” on page 2-1 for further information about the functionality of the Symbolic, Numeric, and Plot views.

## Getting started with the Function applet

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

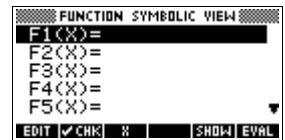
### Open the Function applet

1. Open the Function applet.

 Select Function



The Function applet starts in the Symbolic view.

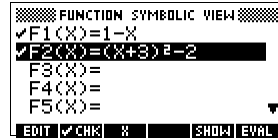


The Symbolic view is the *defining* view for Function, Parametric, Polar, and Sequence applets. The other views are derived from the symbolic expression.

## Define the expressions

- 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 ]** **[ ) ]** **[ X<sup>2</sup> ]**  
**[ - ]** **[ 2 ]** **[ENTER]**

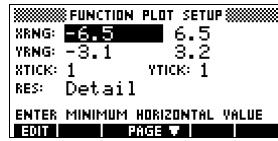


## Set up the plot

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

- Display plot settings.

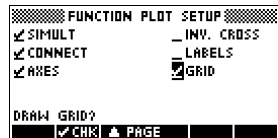
**SHIFT** SETUP-PLOT



*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.*

- Specify a grid for the graph.

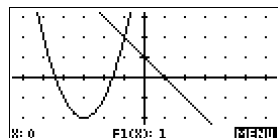
**ENTER**  
**[▶]** **[▼]** **[▼]** **[F2/F3]**



## Plot the functions

- Plot the functions.

**[PLOT]**

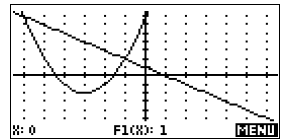




## Change the scale

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 2-14 for a description of `Auto Scale`).

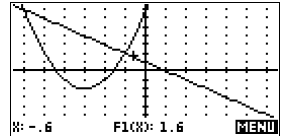
`VIEWS` `Select Auto`  
 Scale `OK`



## Trace a graph

7. Trace the linear function.

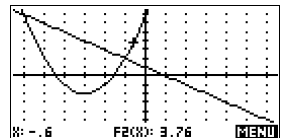
`←` 6 times



*Note: By default, the tracer is active.*

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

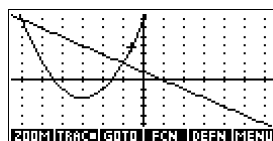
`▲`



## 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 3-10 for further information.

## To find a root of the quadratic function

10. 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.

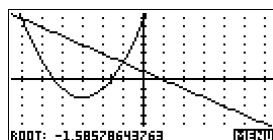
**FCN** SelectRoot

**OK**



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

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



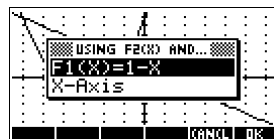
## To find the intersection of the two functions

11. Find the intersection of the two functions.

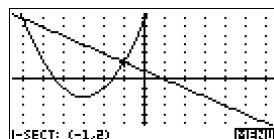
**MENU** **FCN** **▼** **OK**



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



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

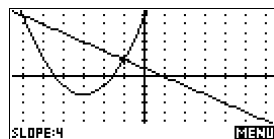
13. Find the slope of the quadratic function at the intersection point.



Select Slope



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

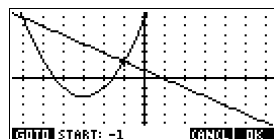


### To find the signed area of the two functions

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

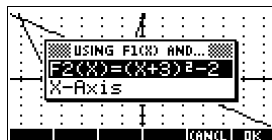


Select Signed area



15. Move the cursor to  $x = -1$  by pressing the  $\blacktriangleleft$  or  $\blacktriangleright$  key.

$\text{DIS}$



16. Press  $\text{DIS}$  to accept using  $F2(x) = (x + 3)^2 - 2$  as the other boundary for the integral.

17. Choose the end value for  $x$ .

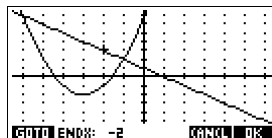
$\text{GOTO}$

$(-)$  2

$\text{DIS}$



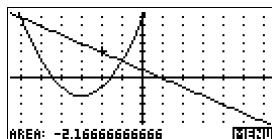
The cursor jumps to  $x = -2$  on the linear function.



18. Display the numerical value of the integral.

$\text{DIS}$

*Note: See "Shading area" on page 3-11 for another method of calculating area.*



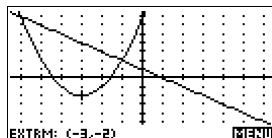
## To find the extremum of the quadratic

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

$\blacktriangle$   $\text{MENU}$   $\text{EQN}$

Select Extremum  $\text{DIS}$

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**

X	F1	F2	
0	1	7	
.1	.4	7.61	
.2	.8	8.24	
.4	1.6	8.84	
.5	1.5	10.25	

0

**ZOOM** **BIG** **DEFN**

## Set up the table

21. Display the numeric setup.

**SHIFT** *SETUP-NUM*

FUNCTION NUMERIC SETUP	
NUMSTART:	0
NUMSTEP:	.1
NUMTYPE:	Automatic
NUMZOOM:	4
ENTER STARTING VALUE FOR TABLE	
<b>EDIT</b>	<b>PLT</b>

See "Setting up the table (Numeric view setup)" on page 2-17 for more information.

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

**PLT** **08**

FUNCTION NUMERIC SETUP	
NUMSTART:	-6.5
NUMSTEP:	.1
NUMTYPE:	Automatic
NUMZOOM:	4
ENTER STARTING VALUE FOR TABLE	
<b>EDIT</b>	<b>PLT</b>

## Explore the table

23. Display the table of values.

**NUM**

X	F1	F2	
-6.5	7.56	10.25	
-6.4	7.4	9.56	
-6.3	7.29	8.84	
-6.2	7.16	8.24	
-6.1	7.06	7.61	

-6.5

**ZOOM** **BIG** **DEFN**

**To navigate around a table**

24. Move to  $X = -5.9$ .

▼ 6 times

X	F1	F2
-16.4	266.14	9.56
-16.3	266.13	8.89
-16.2	266.12	8.24
-16.1	266.11	7.61
-5.9	6.9	6.41

10

ROOM | BIG | DEFN |

**To go directly to a value**

25. Move directly to  $X = 10$ .

1 0 **DIR**

X	F1	F2
9.875	-8.875	163.766
9.9	-8.9	164.41
9.925	-8.925	165.056
9.95	-8.95	165.703
10	-9	167

10

ROOM | BIG | DEFN |

**To access the zoom options**

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

**NUMZOOM** In

**DIR**

X	F1	F2
9.875	-8.875	163.766
9.9	-8.9	164.41
9.925	-8.925	165.056
9.95	-8.95	165.703
10	-9	167

10

ROOM | BIG | DEFN |

**To change font size**

27. Display table numbers in large font.

**BIG**

X	F1	F2
9.875	-8.875	163.766
9.9	-8.9	164.41
9.925	-8.925	165.056
9.95	-8.95	165.703
9.95		

10

ROOM | BIG | DEFN |

**To display the symbolic definition of a column**

28. Display the symbolic definition for the F1 column.

▶ **DEFN**

X	F1	F2
9.875	-8.875	163.766
9.9	-8.9	164.41
9.925	-8.925	165.056
9.95	-8.95	165.703
1-X		

10

ROOM | BIG | DEFN |

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

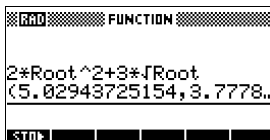
# Function applet interactive analysis

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 applet (and any Function-based applets). See “FCN functions” on page 3-10. 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 on the VARS menu.

To access FCN variables in HOME:



Select Plot FCN



▲ or ▼ to choose a

variable



To access FCN variable in the Function applet’s Symbolic view:



Select Plot FCN



▲ or ▼ to choose a variable



## FCN functions

The FCN functions are:

Function	Description
Root	Select <code>Root</code> 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 <code>EXTR:</code> instead of <code>ROOT:</code> . (The root-finder is also used in the Solve applet. 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 <code>ROOT</code> .
Extremum	Select <code>Extremum</code> 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 <code>EXTREMUM</code> .
Slope	Select <code>Slope</code> to find the numeric derivative at the current position of the cursor. The result is saved in a variable named <code>SLOPE</code> .
Signed area	Select <code>Signed area</code> 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 <code>AREA</code> .



Function	Description (Continued)
Intersection	Select <b>Intersection</b> to find the intersection of two graphs nearest the cursor. <i>(You need to have at least two selected expressions in Symbolic view.)</i> 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 applet. The Function applet 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 the 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.

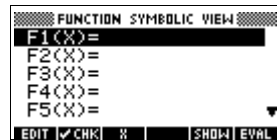
# Plotting a piecewise-defined function

Suppose you wanted to plot the following piecewise-defined function.

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

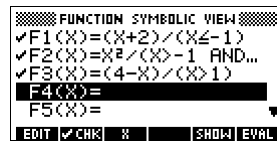
1. Open the Function aplet.

**APLET** Select  
Function  
**START**

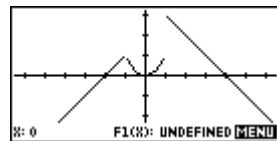


2. Highlight the line you want to use, and enter the expression. (You can press **DEL** to delete an existing line, or **SHIFT** CLEAR to clear all lines.)

**(** **+** **2** **)** **÷**  
**(** **+** **SHIFT** CHARS **≤**  
**(-)** **1** **)** **ENTER**  
**+** **X<sup>2</sup>** **÷** **(** **+**  
**SHIFT** CHARS **>** **(-)** **1**  
**SHIFT** AND **+** **SHIFT** CHARS **≤** **1** **)** **ENTER**



**(** **4** **-** **+** **)** **÷** **(**  
**+**  
**SHIFT** CHARS **>** **1** **)**  
**ENTER**



*Note: You can use the **+** menu key to assist in the entry of equations. It has the same effect as pressing*

**X,T,θ** .

# Parametric applet

## About the Parametric applet

The Parametric applet 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 applet

The following example uses the parametric equations

$$\begin{aligned}x(t) &= 3 \sin t \\y(t) &= 3 \cos t\end{aligned}$$

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

### Open the Parametric applet

1. Open the Parametric applet.

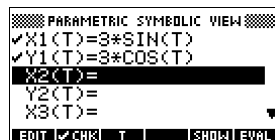
Select  
Parametric



### Define the expressions

2. Define the expressions.

3      
  
3



## Set angle measure

- Set the angle measure to degrees.

**SHIFT** MODES

**CHOOSE**

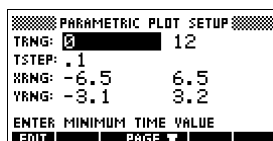
Select Degrees **OK**



## Set up the plot

- Display the graphing options.

**SHIFT** PLOT

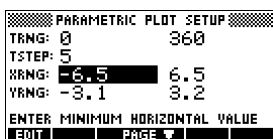


The Plot Setup input form has two fields not included in the Function aplet, TRNG and TSTEP. TRNG specifies the range of  $t$  values. TSTEP specifies the step value between  $t$  values.

- Set the TRNG and TSTEP so that  $t$  steps from  $0^\circ$  to  $360^\circ$  in  $5^\circ$  steps.

**▶** 360 **OK**

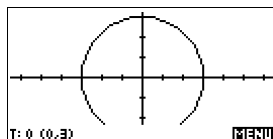
5 **OK**



## Plot the expression

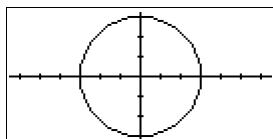
- Plot the expression.

**PLOT**



- 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 **MEMO**

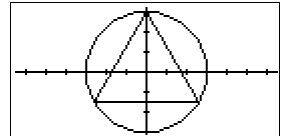
**VIEWS**

Select Overlay Plot



**MENU** **MENU**

PARAMETRIC PLOT SETUP	
TRNG:	0 360
TSTEP:	120
XRNG:	-6.5 6.5
YRNG:	-3.1 3.2
ENTER MINIMUM HORIZONTAL VALUE	
<b>EDIT</b>	<b>PAGE</b>



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 applet. See “Exploring the graph” on page 2-7 for further information.

## Display the numbers

9. Display the table of values.

**NUM**

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.

T	X1	Y1
0	0	0
1	.005236	2.444445
2	.010472	2.444482
3	.0157079	2.444519
4	.0209438	2.444557
5	.0261796	2.444596

**ZOOM** **BIG** **DEFN**

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



# Polar aplet

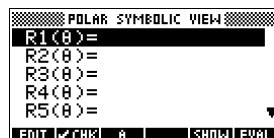
## Getting started with the Polar aplet

### Open the Polar aplet

1. Open the Polar aplet.

*Select Polar*

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

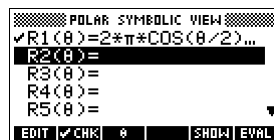


### Define the expression

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

2

2



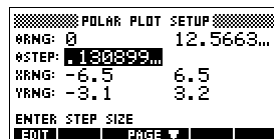
### Specify plot settings

3. Specify the plot settings. In this example, we will use the default settings, except for the  $\theta$  RING fields.

*SETUP-PLOT*

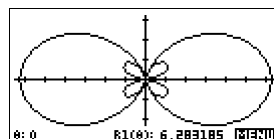
*CLEAR*

4



### Plot the expression

4. Plot the expression.

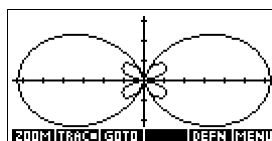


## Explore the graph

5. Display the Plot view menu key labels.

**PLT**

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 for  $\theta$  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.

$\theta$	R1		
0	6.283185		
1	6.212789		
2	6.005094		
3	5.670064		
4	5.241094		
5	4.68857		



# Sequence applet

---

## About the Sequence applet

The Sequence applet 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.

The Sequence applet allows you to create two types of graphs:

- 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.

## Getting started with the Sequence applet

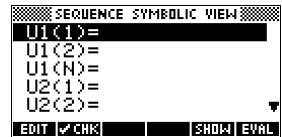
The following example defines and then plots an expression in the Sequence applet.

### Open the Sequence applet

1. Open the Sequence applet.

Select  
Sequence

The Sequence applet starts in the Symbolic view.



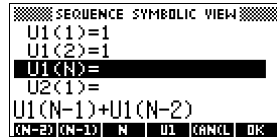
## Define the expression

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

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

In the Symbolic view of the Sequence aplet, highlight the  $U_1(1)$  field and begin defining your sequence.

1 [ENTER] 1 [ENTER]  
 $U_1(N-1)$  +  $U_1$   
 $U_1(N-2)$

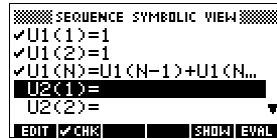


Note: You can use the

$N$ ,  $U_1(N-2)$ ,  $U_1(N-1)$ ,  $U_1$ ,

and  $U_2$  menu keys to assist in the entry of equations.

[ENTER]



## Specify plot settings

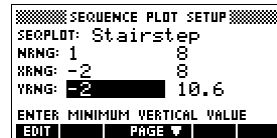
- In Plot Setup, first set the SEQPLOT option to Stairstep. Reset the default plot settings by clearing the Plot Setup view.

[SHIFT] SETUP-PLOT

[SHIFT] CLEAR

[DOWN] [RIGHT] 8 [ENTER]

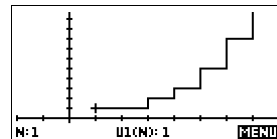
[RIGHT] 8 [ENTER]



## Plot the sequence

- Plot the Fibonacci sequence.

[PLOT]



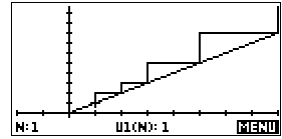
- In Plot Setup, set the SEQPLOT option to Cobweb.

[SHIFT] SETUP-PLOT

**CHOOSE** Select Cobweb

**OK**

**PLOT**



## Display the table

6. Display the table of values for this example.

**NUM**

N	U1		
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

**ZOOM** **SIG** **DEFN**



# 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  $\theta$ .
- 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 applet.

## Getting started with the Solve applet

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 applet

1. Open the Solve applet.

**APLET** Select Solve  
**START**

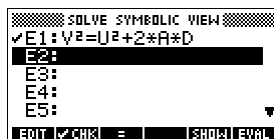
The Solve applet starts in the symbolic view.



### Define the equation

2. Define the equation.

**ALPHA** V **X<sup>2</sup>**  
**≡** **ALPHA** U **X<sup>2</sup>**  
**+** **2** **x**  
**ALPHA** A **x**  
**ALPHA** D **ENTER**

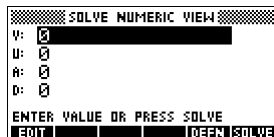


*Note: You can use the **≡** menu key to assist in the entry of equations.*

### Enter known variables

3. Display the Solve numeric view screen.

**NUM**



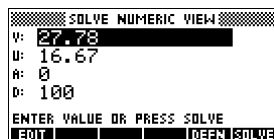
4. Enter the values for the known variables.

27 [.] 78 [ENTER]

16 [.] 67 [ENTER]



100 [ENTER]



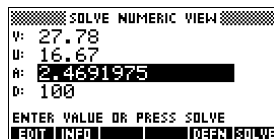
## HINT

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  $2.47 \text{ m/s}^2$ .

Because the variable  $A$  in the equation is linear we know that we need not look for any other solutions.

## Plot the equation

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

The current equation is  $V^2 = U^2 + 2AD$ .

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

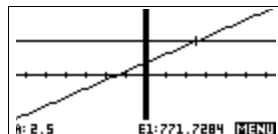
6. Plot the equation for variable  $A$ .

**VIEWS** Select Auto  
Scale  
**□**



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

**▶**  $\approx 20$  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 instead of using the Numeric view Solve option. See “Plotting to find guesses” on page 7-7 for more information.

## Solve aplet’s NUM view keys

The Solve aplet’s NUM view keys are:

Key	Meaning
<b>EDIT</b>	Copies the highlighted value to the edit line for editing. Press <b>□</b> when done.
<b>INFO</b>	Displays a message about the solution (see “Interpreting results” on page 7-6).
<b>PAGE</b>	Displays other pages of variables, if any.
<b>DEFN</b>	Displays the symbolic definition of the current expression. Press <b>□</b> when done.
<b>SOLVE</b>	Finds a solution for the highlighted variable, based on the values of the other variables.



Key	Meaning (Continued)
<code>DEL</code>	Clears highlighted variable to zero or deletes current character in edit line, if edit line is active.
<code>SHIFT CLEAR</code>	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 7-7 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 1-10 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 <i>either</i> the two points are neighbours (they differ by one in the twelfth digit), <i>or</i> 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 9.999999999999E499, 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 applet 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 applet 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:

$$X = V_0T + \frac{AT^2}{2}$$

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 **SOLVE**

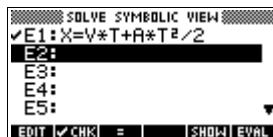
**ALPHA** X **⊗**

**ALPHA** V **⊗**

**ALPHA** T **+**

**ALPHA** A

**⊗** **ALPHA** T **X<sup>2</sup>** **=** 2 **⊗**



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,  $T$ .

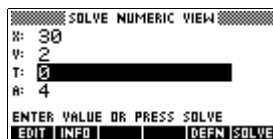
**NUM**

30 **ENTER**

2 **ENTER**

**▼** 4 **ENTER**

**▼** **▼** to highlight  $T$

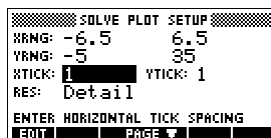


3. Use the Plot view to find an initial guess for  $T$ . First set appropriate  $X$  and  $Y$  ranges in the Plot Setup. With equation  $X = V x T + A x T^2 / 2$ , the plot will produce two graphs: one for  $Y = X$  and one for  $Y = V x T + A x T^2 / 2$ . Since we have set  $X = 30$  in this example, 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**

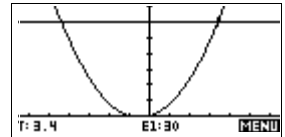


4. Plot the graph.

**PLOT**

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

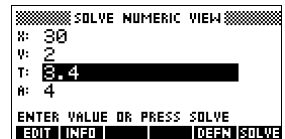
Press  $\blacktriangleright$  until the cursor is at the intersection.



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.

- Return to the Numeric view.

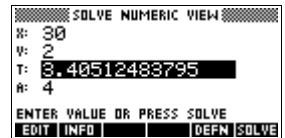
$\boxed{\text{NUM}}$



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

- Ensure that the  $T$  value is highlighted, and solve the equation.

$\boxed{\text{SOLVE}}$

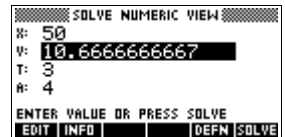


Use this equation to solve for another variable, such as velocity. How fast must a body's initial velocity be in order for it to travel 50 m within 3 seconds? Assume the same acceleration,  $4 \text{ m/s}^2$ . Leave the last value of  $V$  as the initial guess.

3  $\boxed{\text{ENTER}}$   $\blacktriangle$   $\blacktriangle$   $\blacktriangle$

50  $\boxed{\text{ENTER}}$

$\boxed{\text{SOLVE}}$



## Using variables in equations

You can use any of the real variable names, A to Z and  $\theta$ . 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 whenever it is recalculated.

#### HINT

---

As the Solve aplet uses 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  $X^2 + 10 = 50$ .

# Statistics applet

---

## About the Statistics applet

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

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

## Getting started with the Statistics applet

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**.

Select Statistics

n	C1	C2	C3	C4
1				
<input type="button" value="EDIT"/> <input type="button" value="INS"/> <input type="button" value="SORT"/> <input type="button" value="BIG"/> <input type="button" value="1VAR"/> <input type="button" value="STATS"/>				

The Statistics aplet starts in the Numerical view.

1VAR/2VAR  
menu key label

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  1   
 3  5   
 5  4

n	C1	C2	C3	C4
1		1400		
2		920		
3		1100		
4		2265		
5		2890		
6		2200		
1400				
<input type="button" value="EDIT"/> <input type="button" value="INS"/> <input type="button" value="SORT"/> <input type="button" value="BIG"/> <input type="button" value="1VAR"/> <input type="button" value="STATS"/>				

to move to the next column

1400  920   
 1100  2265   
 2890  2200



# Choose fit and data columns

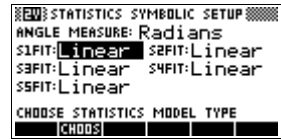
- Select a fit in the Symbolic setup view.

**SHIFT** SETUP-SYMB

**CHOOSE**

Select Linear

**OK**

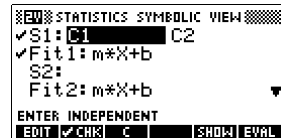


You can create up to five explorations of two-variable data, named S1 to S5. In this example, we will create just one: S1.

- 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

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

**NUM** **STATS**

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

Z-VAR	S1		
MEANX	3.333333		
ZV	80		
ZV2	80		
MEANY	1795.833		
ZV	10775		
ZV2	22388725		
3.333333333333			
<b>OK</b>			

- 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 .8995.

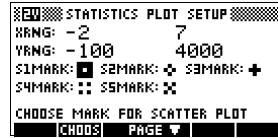
**OK**

Z-VAR	S1		
ZV2	22388725		
ZV1	41595		
SCDV	1135.667		
PCDV	846.8889		
CORR	.899509		
RELERR	.025524		
.89950938561			
<b>OK</b>			

## Setup plot

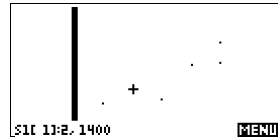
- Change the plotting range to ensure all the data points are plotted (and select a different point mark, if you wish).

7   
 100   
 4000



## Plot the graph

- Plot the graph.



## Draw the regression curve

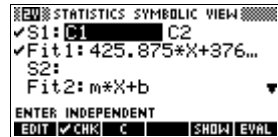
- Draw the regression curve (a curve to fit the data points).

This draws the regression line for the best linear fit.



## Display the equation for best linear fit

- Return to the Symbolic view.

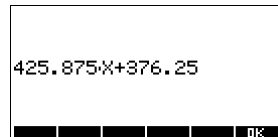


- Display the equation for the best linear fit.

to move to the  
 FIT1 field

The full FIT1 expression is shown.

The slope ( $m$ ) is 425.875. The y-intercept ( $b$ ) is 376.25.



## Predict values

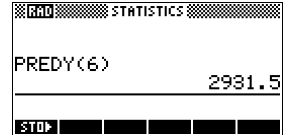
13. To find the predicted sales figure if advertising were to go up to 6 minutes:

**2nd** HOME

**MATH** S (to highlight Stat-Two)

**▶ ▲** (to highlight PREDY)

**2nd** 6 ENTER



14. Return to the Plot view.

**PLOT**



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

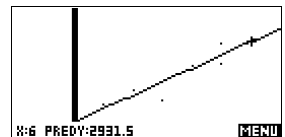
**▼** **GOTO**

6



**2nd**

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 applet. 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 applet's NUM view keys

The Statistics applet's Numeric view keys are:

Key	Meaning
<b>EDIT</b>	Copies the highlighted item into the edit line.
<b>INS</b>	Inserts a zero value above the highlighted cell.
<b>SORT</b>	Sorts the specified <i>independent</i> data column in ascending or descending order, and rearranges a specified dependent (or frequency) data column accordingly.
<b>BIG</b>	Switches between larger and smaller font sizes.
<b>1VAR</b> <b>2VAR</b>	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.
<b>STATS</b>	Computes descriptive statistics for each data set specified in Symbolic view.

Key	Meaning (Continued)
<input type="button" value="DEL"/>	Deletes the currently highlighted value.
<input type="button" value="SHIFT"/> <i>CLEAR</i>	Clears the current column or all columns of data. Presses <input type="button" value="SHIFT"/> <i>CLEAR</i> to display a menu list, then select the current column or all columns option, and press <input type="button" value="OK"/> .
<input type="button" value="SHIFT"/> <i>cursor key</i>	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 applet.

*Select*  
Statistics

n	C1	C2	C3	C4
1				

EDIT INS SORT BIG LVAR=STATS

2. Enter the measurement data.

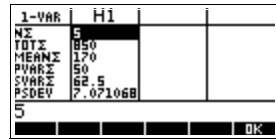
160   
165   
170   
175   
180

n	C1	C2	C3	C4
1	160			
2	165			
3	170			
4	175			
5	180			

EDIT INS SORT BIG LVAR=STATS

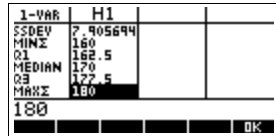
3. Find the mean of the sample.

Ensure the **1VAR** / **2VAR** menu key label reads **1VAR**. Press



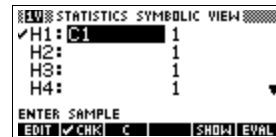
**STAT** to see the statistics calculated from the sample data in C1.

Note that the title of 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
<b>EDIT</b>	Copies the column variable (or variable expression) to the edit line for editing. Press <b>OK</b> when done.
<b>CHK</b>	Checks/unchecks the current data set. Only the checkmarked data set(s) are computed and plotted.
<b>C</b> or <b>▣</b>	Typing aid for the column variables ( <b>C</b> ) or for the Fit expressions ( <b>▣</b> ).

<b>Key</b>	<b>Meaning (Continued)</b>
<b>SHOW</b>	Displays the current variable expression in standard mathematical form. Press <b>ON</b> when done.
<b>EQUAL</b>	Evaluates the variables in the highlighted column (C1, etc.) expression.
<b>VAR</b>	Displays the menu for entering variable names or contents of variables.
<b>MATH</b>	Displays the menu for entering math operations.
<b>DEL</b>	Deletes the highlighted variable or the current character in the edit line.
<b>SHIFT</b> CLEAR	Resets default specifications for the data sets or clears the edit line (if it was active). <i>Note: If <b>SHIFT</b> CLEAR is used the data sets will need to be selected again before re-use.</i>

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.

<b>Height (cm)</b>	<b>Frequency</b>
160	5
165	3
170	8
175	2
180	1

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

STATISTICS SYMBOLIC VIEW	
✓H1: C1	C2
H2:	1
H3:	1
H4:	1
ENTER SAMPLE	
EDIT	✓CHK C
SHOW	EVAL

**2**

- Return to the numeric view.

**NUM**

- Enter the frequency data shown in the above table.

**5** **ENTER**

**3** **ENTER**

**8** **ENTER**

**2** **ENTER**

**1** **ENTER**

n	C1	C2	C3	C4
1	160	5		
2	165			
3	170			
4	175			
5	180			

EDIT INE SORT BIG LVAR STATS

- Display the computed statistics.

**STATS**

The mean height is approximately 167.63cm.

1-VAR	H1
NΣ	19
TOTΣ	3185
MEANΣ	167.6316
PVARΣ	32.54848
SVARΣ	34.35679
PSDEV	5.705127
167.631578947	

OK

- Setup a histogram plot for the data.

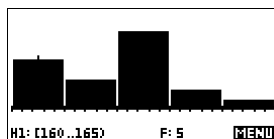
**2ND** **SHIFT** **SETUP-PLT**

Enter set up information appropriate to your data.

STATISTICS PLOT SETUP	
STATPLOT: Hist	HWIDTH: 5
XNRNG: 160	185
YNRNG: -2	10
HRNG: 160	185
ENTER MAXIMUM HISTOGRAM VALUE	
EDIT	PAGE

- Plot a histogram of the data.

**PLOT**



## 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 applet, 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. Specify the Sort Order. 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

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.*

## 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.

## To choose the fit

1. In Numeric view, make sure **EWAVE** 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 **[CHOOSE]** and select from the 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
Lineair	(Default.) Fits the data to a straight line, $y = mx + b$ . Uses a least-squares fit.
Logaritmisch	Fits to a logarithmic curve, $y = m \ln x + b$ .
Macht	Fits to an exponential curve, $y = be^{mx}$ .
Power	Fits to a power curve, $y = bx^m$ .

Fit model	Meaning (Continued)
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 **EDIT** 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).

<b>Statistic</b>	<b>Definition (Continued)</b>
MEAN $\Sigma$	Mean value of data set.
PVAR $\Sigma$	Population variance of data set.
SVAR $\Sigma$	Sample variance of data set.
PSDEV	Population standard deviation of data set.
SSDEV	Sample standard deviation of data set.
MIN $\Sigma$	Minimum data value in data set.
Q1	First quartile: median of values to left of median.
MEDIAN	Median value of data set.
Q3	Third quartile: median of values to right of median.
MAX $\Sigma$	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

<b>Statistic</b>	<b>Definition</b>
MEANX	Mean of $x$ - (independent) values.
$\Sigma X$	Sum of $x$ -values.
$\Sigma X^2$	Sum of $x^2$ -values.
MEANY	Mean of $y$ - (dependent) values.
$\Sigma Y$	Sum of $y$ -values.

Statistic	Definition (Continued)
$\Sigma Y^2$	Sum of $y^2$ -values.
$\Sigma XY$	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 <i>for a linear fit only</i> (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 (**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 plot 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 (**WCHK**) 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 **CHOOSE**, select either Histogram or BoxWhisker, and press **OK**.

- 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 by adjusting the `HWIDTH` setting.
- Press `.` If you have not adjusted the Plot Setup `[PLOT]` yourself, you can try `[VIEWS]` *select* `Auto Scale` `[OK]`.

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

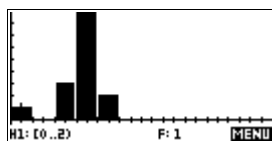
## Plot types

### 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.

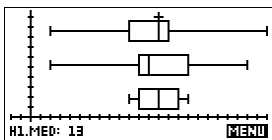


### Box and Whisker Plot

#### One-variable statistics.

The left whisker marks the minimum data value. The box marks the first quartile, the median (where the cursor is), and the third quartile.

The right whisker marks the maximum data value. The numbers below the plot mean that this column has a median of 13.



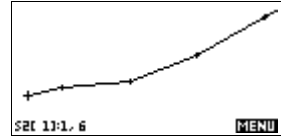
### Scatter Plot

#### 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.*



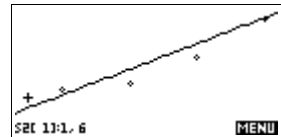
## Fitting a curve to 2VAR data

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 8-12.

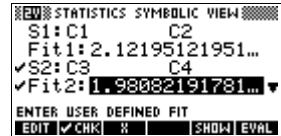
PLOT

**MENU**

**FIT**

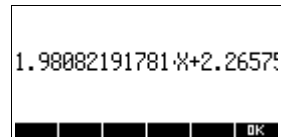


SYMB



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

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.

## HINT

---

In order to access the `CORR` and `RELERR` 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 `[LVAR]` is set). Press `[CHOOSE]` 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 `[CHOOSE]` 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 **DUARR** or **DUARR** 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 **DUARR** mode, ensure that both paired columns contain data, and that they are the same length.

In **DUARR** 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 applet’s PLOT view keys

Key	Meaning
<b>SHIFT</b> <i>CLEAR</i>	Erases the plot.
<b>VIEWS</b>	Offers additional pre-defined views for splitting the screen, overlaying plots, and autoscaling the axes.
<b>SHIFT</b> ◀	Moves cursor to far left or far right.
<b>SHIFT</b> ▶	
<b>ZOOM</b>	Displays ZOOM menu.
<b>TRACE</b>	Turns trace mode on/off. The white box appears next to the option when Trace mode is active.

Key	Meaning (Continued)
<b>FIT</b>	Turns fit mode on or off. Turning <b>FIT</b> on draws a curve to fit the data points according to the current regression model.
<b>F010</b> (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.
<b>DEFN</b>	Displays the equation of the regression curve.
<b>MENU</b>	Hides and displays the menu key labels. When the labels are hidden, any menu key displays the (x,y) coordinates. Pressing <b>MENU</b> redisplay 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 **F010** and enter the value of  $X$ . The cursor jumps to the specified point on the curve and the coordinate display shows  $X$  and the predicted value of  $Y$ .

In HOME,

- Enter **PREDX(y-value)** **ENTER** to find the predicted 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.

---



# Inference applet

---

## About the Inference applet

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 applet

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

### Open the Inference applet

1. Open the Inference applet.

APLET

Select Inference

RESET VIEW STAT.

The Inference applet opens in the Symbolic view.

```

INF STAT SYMBOLIC VIEW
METHOD: HYPOTH TEST
TYPE: Z-Test: 1 μ
ALT HYPOTH: μ<μ0
Choose an inferential method
ICHOOS
  
```

## Inference applet's SYMB view keys

The table below summarizes the options available in Symbolic view.

<b>Hypothesis Tests</b>	<b>Confidence Intervals</b>
Z: $1 \mu$ , the Z-Test on 1 mean	Z-Int: $1 \mu$ , 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: $1 \pi$ , the Z-Test on 1 proportion	Z-Int: $1 \pi$ , the confidence interval for 1 proportion, based on the Normal distribution
Z: $\pi_1 - \pi_2$ , the Z-Test on the difference in two proportions	Z-Int: $\pi_1 - \pi_2$ , the confidence interval for the difference of two proportions, based on the Normal distribution
T: $1 \mu$ , the T-Test on 1 mean	T-Int: $1 \mu$ , 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

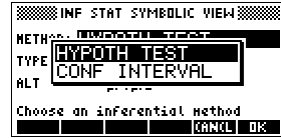
If you choose one of the hypothesis tests, you can choose the alternative hypothesis to test against the null hypothesis. For each test, there are three possible choices for an alternative hypothesis based on a quantitative comparison of two quantities. The null hypothesis is always that the two quantities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

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

## Select the inferential method

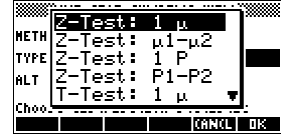
2. Select the Hypothesis Test inferential method.

**CHOOSE**  
Select HYPOTH TEST



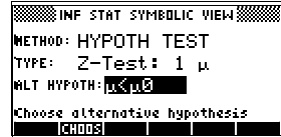
3. Define the type of test.

**OK** ▼  
**CHOOSE**  
Z-Test: 1  $\mu$



4. Select an alternative hypothesis.

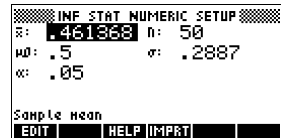
**OK** ▼  
**CHOOSE**  
 $\mu < \mu_0$   
**OK**



## Enter data

5. Enter the sample statistics and population parameters.

**SHIFT** setup-NUM



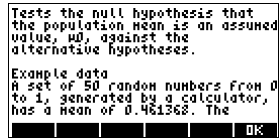
The table below lists the fields in this view for our current Z-Test: 1  $\mu$  example.

Field name	Definition
$\mu_0$	Assumed population mean
$\sigma$	Population standard deviation
$\bar{x}$	Sample mean
$n$	Sample size
$\alpha$	Alpha level for the test

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

## Display on-line help

- To display the on-line help, press **F1**.
- To close the on-line help, press **F2**.

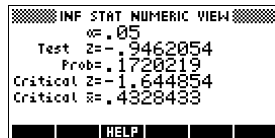


## Display test results in numeric format

- 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.



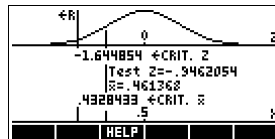
*Note: You can access the on-line help in Numeric view.*

## Plot test results

- 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  $\leftarrow R$  and the test numeric results are displayed between the horizontal axes.



## Importing sample statistics from the Statistics applet

The Inference applet supports the calculation of confidence intervals and the testing of hypotheses based on data in the Statistics applet. Computed statistics for a sample of data in a column in any Statistics-based applet can be imported for use in the Inference applet. 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 the Statistics aplet and reset the current settings.

APLET Select  
Statistics  
RESET YES  
STAT

n	C1	C2	C3	C4
1				

EDIT INS SORT BIG IVAR=STATS

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

n	C1	C2	C3	C4
1	.529			
2	.295			
3	.952			
4	.259			
5	.925			
6	.592			

EDIT INS SORT BIG IVAR=STATS

## 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 **I-VAR** is displayed as its menu label.

## Calculate statistics

4. Calculate statistics.

STATS

The mean of 0.592 seems a little large compared to the

1-VAR	H1		
NΣ	6		
TOTΣ	3.592		
MEANΣ	.592		
PVARΣ	.023926		
SVARΣ	.0882112		
PSDEV	.2710434		
Σ			

OK

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 **EXIT** to close the computed statistics window.

## Open Inference aplet

6. Open the Inference applet and clear current settings.

**APLET** Select  
Inference  
**RESET** **YES**  
**START**

```
INF STAT SYMBOLIC VIEW
METHOD: HYPOTH TEST
TYPE: Z-Test: 1 μ
ALT HYPOTH: μ < μ0
Choose an inferential Method
[CHOOSE]
```

## Select inference method and type

7. Select an inference method.

**CHOOSE**  
Select CONF INTERVAL  
**OK**

```
INF STAT SYMBOLIC VIEW
METHOD: CONF INTERVAL
TYPE: Z-INT: 1 μ
Choose an inferential Method
[CHOOSE]
```

8. Select a distribution statistic type.

**▼** **CHOOSE**  
Select T-Int: 1 μ  
**OK**

```
INF STAT SYMBOLIC VIEW
METHOD: CONF INTERVAL
TYPE: T-INT: 1 μ
Choose distribution statistic
[CHOOSE]
```

## Set up the interval calculation

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

**SHIFT** Setup-NUM

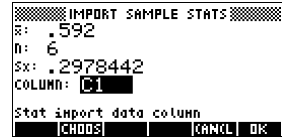
```
INF STAT NUMERIC SETUP
x: .461368
sx: .2776
n: 50
c: .99
Sample Mean
[EDIT] [HELP] [IMPRT]
```

## Import the data

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



*Note: Press **IMP** 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.*

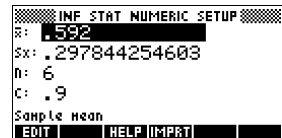


11. Specify a 90% confidence interval in the C: field.



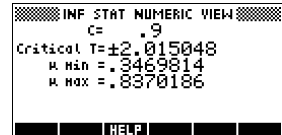
▼ ▼ ▼ to move to the C: field

0.9



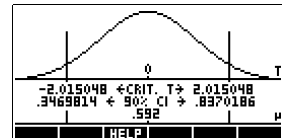
## Display Numeric view

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



## Display Plot view

13. Display the confidence interval in the Plot view.



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+ hypothesis tests use the Normal Z-distribution or Student's t-distribution to calculate probabilities.

## One-Sample Z-Test

### Menu name

Z-Test: 1  $\mu$

On the basis of statistics from a single sample, the One-Sample 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:

$$H_1: \mu_1 < \mu_2$$

$$H_1: \mu_1 > \mu_2$$

$$H_1: \mu_1 \neq \mu_2$$

### Inputs

The inputs are:

Field name	Definition
$\bar{x}$	Sample mean.
n	Sample size.
$\mu_0$	Hypothetical population mean.
$\sigma$	Population standard deviation.
$\alpha$	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 $\alpha$ level that you supplied.
Critical $\bar{x}$	Boundary values of $\bar{x}$ required by the $\alpha$ value that you supplied.

## Two-Sample Z-Test

### Menu name

Z-Test:  $\mu_1 - \mu_2$

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.
$n_1$	Sample 1 size.
$n_2$	Sample 2 size.
$\sigma_1$	Population 1 standard deviation.

Field name	Definition
$\sigma_2$	Population 2 standard deviation.
$\alpha$	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 $\alpha$ level that you supplied.

## One-Proportion Z-Test

### Menu name

Z-Test:  $1\pi$

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.
$\pi_0$	Population proportion of successes.
$\alpha$	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:  $\pi_1 - \pi_2$

On the basis of statistics from two samples, each from a different population, the Two-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.
$\alpha$	Significance level.

## Results

The results are:

Result	Description
Test $\pi_1 - \pi_2$	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 $\alpha$ level that you supplied.

# One-Sample T-Test

## Menu name

T-Test: 1  $\mu$

The One-sample T-Test is used when the population standard deviation is not known. On the basis of statistics from a single sample, 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.
$S_x$	Sample standard deviation.
$n$	Sample size.
$\mu_0$	Hypothetical population mean.
$\alpha$	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 $\alpha$ level that you supplied.
Critical $\bar{x}$	Boundary value of $\bar{x}$ required by the $\alpha$ value that you supplied.

# Two-Sample T-Test

## Menu name

T-Test:  $\mu_1 - \mu_2$

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.
$\alpha$	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 $\alpha$ level that you supplied.

## Confidence intervals

The confidence interval calculations that the hp 39g+ can perform are based on the Normal Z-distribution or Student's t-distribution.

## One-Sample Z-Interval

### Menu name

Z-INT:  $\mu$  1

This option uses the Normal Z-distribution to calculate a confidence interval for  $m$ , the true mean of a population, when the true population standard deviation,  $s$ , is known.

### Inputs

TheT inputs are:

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

## Results

The results are:

Result	Description
Critical Z	Critical value for Z.
$\mu$ min	Lower bound for $\mu$ .
$\mu$ max	Upper bound for $\mu$ .

## Two-Sample Z-Interval

### Menu name

Z-INT:  $\mu_1 - \mu_2$

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,  $\sigma_1$  and  $\sigma_2$ , 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.
$\sigma_1$	Population 1 standard deviation.
$\sigma_2$	Population 2 standard deviation.
C	Confidence level.

## Results

The results are:

Result	Description
Critical Z	Critical value for Z.
$\Delta \mu$ Min	Lower bound for $\mu_1 - \mu_2$ .
$\Delta \mu$ Max	Upper bound for $\mu_1 - \mu_2$ .

# One-Proportion Z-Interval

**Menu name** Z-INT:  $1 \pi$

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.
$\pi$ Min	Lower bound for $\pi$ .
$\pi$ Max	Upper bound for $\pi$ .

# Two-Proportion Z-Interval

**Menu name** Z-INT:  $\pi 1 - \pi 2$

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.

Field name	Definition (Continued)
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  $\mu$

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

### Inputs

The inputs are:

Field name	Definition
$\bar{x}_1$	Sample mean.
Sx	Sample standard deviation.
n	Sample size.
c	Confidence level.

## Results

The results are:

Result	Description
Critical T	Critical value for T.
$\mu$ Min	Lower bound for $\mu$ .
$\mu$ Max	Upper bound for $\mu$ .

## Two-Sample T-Interval

### Menu name

T-INT:  $\mu_1 - \mu_2$

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,  $s_1$  and  $s_2$ , are unknown.

### Inputs

The inputs are:

Field name	Definition
$\bar{x}_1$	Sample 1 mean.
$\bar{x}_2$	Sample 2 mean.
$s_1$	Sample 1 standard deviation.
$s_2$	Sample 2 standard deviation.
$n_1$	Sample 1 size.
$n_2$	Sample 2 size.
C	Confidence level.
_Pooled	Whether or not to pool the samples based on their standard deviations.

## Results

The results are:

<b>Result</b>	<b>Description</b>
Critical T	Critical value for T.
$\Delta \mu$ Min	Lower bound for $\mu_1 - \mu_2$ .
$\Delta \mu$ Max	Upper bound for $\mu_1 - \mu_2$ .

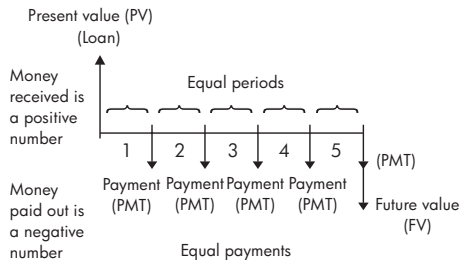




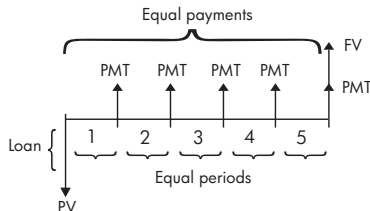
Financial calculations involving compound interest include savings accounts, mortgages, pension funds, leases, and annuities.

Time Value of Money (TVM) calculations, as the name implies, make use of the notion that a dollar today will be worth more than a dollar sometime in the future. A dollar today can be invested at a certain interest rate and generate a return that the same dollar in the future cannot. This TVM principle underlies the notion of interest rates, compound interest and rates of return.

TVM transactions can be represented by using *cash flow diagrams*. A cash flow diagram is a time line divided into equal segments representing the compounding periods. Arrows represent the cash flows, which could be positive (upward arrows) or negative (downward arrows), depending on the point of view of the lender or borrower. The following cash flow diagram shows a loan from a *borrower's* point of view:

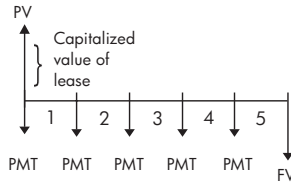


On the other hand, the following cash flow diagram shows a load from the *lender's* point of view:

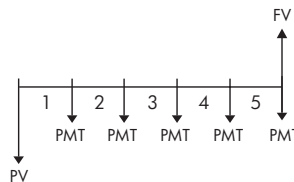


In addition, cash flow diagrams specify *when* payments occur relative to the compounding periods: at the *beginning* of each period or at the *end*. The Finance Solver application provides both of these payment

modes: Begin mode and End mode. The following cash flow diagram shows lease payments at the *beginning* of each period.



The following cash flow diagram shows deposits into an account at the *end* of each period.






As these cash-flow diagrams imply, there are five TVM variables:

N	The total number of compounding periods or payments.
I%YR	The nominal annual interest rate (or investment rate). This rate is divided by the number of payments per year (P/YR) to compute the nominal interest rate <i>per compounding period</i> – which is the interest rate actually used in TVM calculations.
PV	The present value of the initial cash flow. To a lender or borrower, PV is the amount of the loan; to an investor, PV is the initial investment. PV always occurs at the beginning of the first period.

PMT	<p>The periodic payment amount. The payments are the same amount each period and the TVM calculation assumes that no payments are skipped. Payments can occur at the beginning or the end of each compounding period – an option you control by setting the Payment mode to Beg or End.</p>
FV	<p>The future value of the transaction: the amount of the final cash flow or the compounded value of the series of previous cash flows. For a loan, this is the size of the final balloon payment (beyond any regular payment due). For an investment this is the cash value of an investment at the end of the investment period.</p>

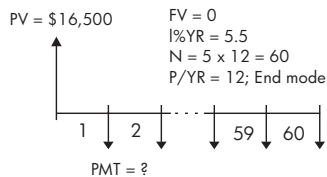
## Performing TVM calculations

1. Launch the Financial Solver as indicated at the beginning of this section.
2. Use the arrow keys to highlight the different fields and enter the known variables in the TVM calculations, pressing the  soft-menu key after entering each known value. Be sure that values are entered for at least four of the five TVM variables (namely, N, I%YR, PV, PMT, and FV).
3. If necessary, enter a different value for P/YR (default value is 12, i.e., monthly payments).
4. Press the key  to change the Payment mode (Beg or End) as required.
5. Use the arrow keys to highlight the TVM variable you wish to solve for and press the  soft menu key.

## Example 1 - Loan calculations

Suppose you finance the purchase of a car with a 5-year loan at 5.5% annual interest, compounded monthly. The purchase price of the car is \$16,500, and the down payment is \$3,000. What are the required monthly payments? What is the largest loan you can afford if your maximum monthly payment is \$300? Assume that the payments start at the end of the first period.

Solution. The following cash flow diagram illustrates the loan calculations:



Start the Finance Solver, selecting P/YR = 12 and End payment option.

- Enter the known TVM variables as shown in the diagram above. Your input form should look as follows:

```

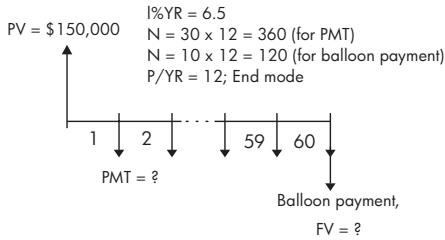
TIME VALUE OF MONEY
N: 60      I%YR: 5.5
PV: 16,500.00
PMT: 0.00  P/YR: 12
FV: 0.00   End
ENTER PAYMENT AMOUNT OR SOLVE
EDIT      AMORT ▾  SOLVE
    
```

- Highlighting the PMT field, press the **SOLVE** soft menu key to obtain a payment of -315.17 (i.e., PMT = -\$315.17).
- To determine the maximum loan possible if the monthly payments are only \$300, type the value -300 in the PMT field, highlight the PV field, and press the **SOLVE** soft menu key. The resulting value is PV = \$15,705.85.

## Example 2 - Mortgage with balloon payment

Suppose you have taken out a 30-year, \$150,000 house mortgage at 6.5% annual interest. You expect to sell the house in 10 years, repaying the loan in a balloon payment. Find the size of the balloon payment – the value of the mortgage after 10 years of payment.

Solution. The following cash flow diagram illustrates the case of the mortgage with balloon payment:



- Start the Finance Solver, selecting P/YR = 12 and End payment option.
- Enter the known TVM variables as shown in the diagram above. Your input form, for calculating monthly payments for the 30-yr mortgage, should look as follows:

```

***** AMORTIZE *****
PAYMENTS: 120
PRINCIPAL: -48,866.27
INTEREST: -70,105.98
BALANCE: 83,497.92
    
```

EDIT TVM B←PV AMOR

- Highlighting the PMT field, press the **SOLVE** soft menu key to obtain a payment of -948.10 (i.e., PMT = -\$948.10)
- To determine the balloon payment or future value (FV) for the mortgage after 10 years, use N = 120, highlight the FV field, and press the **SOLVE** soft menu key. The resulting value is FV = -\$127,164.19. The negative value indicates a payment from the homeowner. Check that the required balloon payments at the end of 20 years (N=240) and 25 years (N = 300) are -\$83,497.92 and -\$48,456.24, respectively.

# Calculating Amortizations

Amortization calculations, which also use the TVM variables, determine the amounts applied towards principal and interest in a payment or series of payments.

## To calculate amortizations:

1. Start the Finance Solver as indicated at the beginning of this section.
2. Set the following TVM variables:
  - a Number of payments per year (P/YR)
  - b Payment at beginning or end of periods
3. Store values for the TVM variables I%YR, PV, PMT, and FV, which define the payment schedule.
4. Press the **AMORT** soft menu key and enter the number of payments to amortize in this batch.
5. Press the **AMT** soft menu key to amortize a batch of payments. The calculator will provide for you the amount applied to interest, to principal, and the remaining balance after this set of payments have been amortized.

## Example 3 - Amortization for home mortgage

For the data of Example 2 above, find the amortization of the loan after the first 10 years ( $12 \times 10 = 120$  payments). Pressing the **AMORT** soft menu key produces the screen to the left. Enter 120 in the PAYMENTS field, and press the **AMT** soft menu key to produce the results shown to the right.

<pre> :~::~: AMORTICE ~::~: PAYMENTS: 12 PRINCIPAL: INTEREST: BALANCE:  ENTER NO. OF PAYMENTS TO AMORT EDIT  TWM  B&gt;PV AMOR           </pre>	<pre> :~::~: AMORTICE ~::~: PAYMENTS: 120 PRINCIPAL: -22,895.81 INTEREST: -90,998.43 BALANCE: 127,164.19           </pre>
-------------------------------------------------------------------------------------------------------------------------------------------------	---------------------------------------------------------------------------------------------------------------------------

## To continue amortizing the loan:

1. Press the **←→** soft menu key to store the new balance after the previous amortization as PV.
2. Enter the number of payments to amortize in the new batch.

3. Press the  $\text{[PMT]}$  soft menu key to amortize the new batch of payments. Repeat steps 1 through 3 as often as needed.

### Example 4 - Amortization for home mortgage

For the results of Example 3, show the amortization of the next 10 years of the mortgage loan. First, press the  $\text{[2]}\rightarrow\text{[PMT]}$  soft menu key. Then, keeping 120 in the PAYMENTS field, press the  $\text{[PMT]}$  soft menu key to produce the results shown below.

```

AMORTIZE
PAYMENTS: 120
PRINCIPAL: -48,666.27
INTEREST: -70,105.98
BALANCE: 83,497.92

EDIT TVM B→PV AMOR

```

### To amortize a series of future payments starting at payment $p$ :

1. Calculate the balance of the loan at payment  $p-1$ .
2. Store the new balance in PV using the  $\text{[2]}\rightarrow\text{[PMT]}$  soft menu key.
3. Amortize the series of payments starting at the new PV.

The amortization operation reads the values from the TVM variables, rounds the numbers it gets from PV and PMT to the current display mode, then calculates the amortization rounded to the same setting. The original variables are not changed, except for PV, which is updated by using  $\text{[2]}\rightarrow\text{[PMT]}$  after each amortization.



# Using mathematical functions

## Math functions

The hp 39g+ 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  $P_{\text{rob}}$  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  $\boxed{\text{MATH}}$ , you see the menu list of Math categories in the left column and the corresponding functions of the highlighted category in the right column. The menu key  $\boxed{\text{MATH}}$  indicates that the MATH FUNCTIONS menu list is active.

### To select a function

1. Press  $\boxed{\text{MATH}}$  to display the MATH menu. The categories appear in alphabetical order. Press  $\boxed{\blacktriangledown}$  or  $\boxed{\blacktriangle}$  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  $\boxed{\text{ALPHA}}$  first.*

- 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.
- Highlight the name of the function you want and press . This copies the function name (and an initial parenthesis, if appropriate) to the edit line.

## Function categories

- Calculus
- Complex numbers
- Constant
- Hyperbolic trigonometry (Hyperb.)
- Lists
- Loop
- Matrices (Matrices)
- Polynomial (Polynom.)
- Probability (Prob.)
- Real numbers (Real)
- Two-variable statistics (Stat-Two)
- Symbolic
- Tests
- Trigonometry (Trig)

# Math functions by category

## 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 MATH menu.

  $\pi$

For a description, see " $\pi$ " on page 11-8.

 ARG

For a description, see "ARG" on page 11-7.

 d/dx

For a description, see " $\partial$ " on page 11-7.

 AND

For a description, see "AND" on page 11-19.

**SHIFT** !

For a description, see “COMB(5,2) returns 10. That is, there are ten different ways that five things can be combined two at a time!” on page 11-12.

**SHIFT**  $\Sigma$

For a description, see “ $\Sigma$ ” on page 11-10.

**SHIFT** *EE*X

For a description, see “Scientific notation (powers of 10)” on page 1-20.

**SHIFT** ]

For a description, see “]” on page 11-7.

**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.

**+**, **-**, **×**, **÷**

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

*value 1* + *value 2*, etc.

**SHIFT**  $e^x$

Natural exponential. Also accepts complex numbers.

$e^{\text{value}}$

### Example

$e^5$  returns 148.413159103

**ln**

Natural logarithm. Also accepts complex numbers.

$\text{LN}(\text{value})$

### Example

$\text{LN}(1)$  returns 0

**SHIFT**  $10^x$

Exponential (antilogarithm). Also accepts complex numbers.

$10^{\text{value}}$

**Example**

$10^3$  returns 1000

**log**

Common logarithm. Also accepts complex numbers.

$\text{LOG}(\text{value})$

**Example**

$\text{LOG}(100)$  returns 2

**SIN**, **COS**, **TAN**

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

$\text{SIN}(\text{value})$

$\text{COS}(\text{value})$

$\text{TAN}(\text{value})$

**Example**

$\text{TAN}(45)$  returns 1 (Degrees mode).

**SHIFT**  $\text{ASIN}$

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

$\text{ASIN}(\text{value})$

**Example**

$\text{ASIN}(1)$  returns 90 (Degrees mode).

**SHIFT**  $\text{ACOS}$

Arc cosine:  $\cos^{-1}x$ . Output range is from  $0^\circ$  to  $180^\circ$ , 0 to  $\pi$ , 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  $-1 \leq x \leq 1$ .

$\text{ACOS}(\text{value})$

**Example**

$\text{ACOS}(1)$  returns 0 (Degrees mode).

**SHIFT** *ATAN*

Arc tangent:  $\tan^{-1}x$ . Output range is from  $-90^\circ$  to  $90^\circ$ ,  $2\pi/2$  to  $\pi/2$ , 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<sup>2</sup>**

Square. Also accepts complex numbers.

*value*<sup>2</sup>

### Example

$18^2$  returns 324

**SHIFT**  $\sqrt{\quad}$

Square root. Also accepts complex numbers.

$\sqrt{\quad}$  *value*

### Example

$\sqrt{324}$  returns 18

**(-)**

Negation. Also accepts complex numbers.

*-value*

### Example

$-(1, 2)$  returns  $(-1, -2)$

**X<sup>Y</sup>**

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

*value*<sup>*power*</sup>

### 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**  $\sqrt[n]{\phantom{x}}$

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 from the keyboard— $\frac{d}{dx}$  and  $\int$  respectively—as well as from the MATH menu.

$\partial$

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 11-21.

$\partial\ variable(expression)$

### Example

$\partial\ s1\ (s1^2+3*s1)$  returns  $2*s1+3$

$\int$

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).

$\int\ (lower,\ upper,\ expression,\ variable)$

See “Using formal variables” on page 11-20 for further details.

### Example

$\int\ (0,\ s1,\ 2*X+3,\ X)$  **ENTER** **▲** **COPY** **ENTER**  
finds the indefinite result  $3*s1+2*(s1^2/2)$

See “To find the indefinite integral using formal variables” on page 11-23 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)<sup>2</sup>, 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+ 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  $1 \times 10^{-499}$ .  
MINREAL
- $\pi$  Internally represented as 3.14159265359.  
 $\pi$

## 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)



<b>TANH</b>	Hyperbolic tangent. <code>TANH(value)</code>
<b>ALOG</b>	Antilogarithm (exponential). This is more accurate than $10^x$ due to limitations of the power function. <code>ALOG(value)</code>
<b>EXP</b>	Natural exponential. This is more accurate than $e^x$ due to limitations of the power function. <code>EXP(value)</code>
<b>EXPM1</b>	Exponent minus 1 : $e^x - 1$ . This is more accurate than EXP when $x$ is close to zero. <code>EXPM1(value)</code>
<b>LNP1</b>	Natural log plus 1 : $\ln(x+1)$ . This is more accurate than the natural logarithm function when $x$ is close to zero. <code>LNP1(value)</code>

## List functions

These functions work on list data. See “List functions” on page 14-6.

## Loop functions

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

<b>ITERATE</b>	Repeatedly for <i>#times</i> evaluates an <i>expression</i> in terms of <i>variable</i> . The value for <i>variable</i> is updated each time, starting with <i>initialvalue</i> . <code>ITERATE (expression, variable, initialvalue, #times)</code>
----------------	--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

### Example

`ITERATE (X2, X, 2, 3)` returns 256

## RECURSE

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

`RECURSE (sequencename, termn, 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).

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

`$\Sigma$  (variable=initialvalue, finalvalue, expression)`

### Example

`$\Sigma$  (C=1, 5, C2)` returns 55.

## Matrix functions

These functions are for matrix data stored in matrix variables. See "Matrix functions and commands" on page 13-9.

## 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  $x^4 + 2x^3 - 25x^2 - 26x + 120$ .

## POLYVAL

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

`POLYVAL ( [coefficients] , value)`

### Example

For  $x^4+2x^3-25x^2-26x+120$ :

`POLYVAL ( [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] )`  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:  $n!/(r!(n-r))!$

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  $\chi^2$  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*.

$UTPF(\textit{numerator}, \textit{denominator}, \textit{value})$

**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.*

$UTPN(\textit{mean}, \textit{variance}, \textit{value})$

**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*.

$UTPT(\textit{degrees}, \textit{value})$

## Real-number functions

Some real-number functions can also take complex arguments.

**CEILING** Smallest integer greater than or equal to *value*.

$CEILING(\textit{value})$

### 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.

$DEG\rightarrow RAD(\textit{value})$

### Example

$DEG\rightarrow RAD(180)$  returns 3.14159265359, the value of  $\pi$ .

**FLOOR** Greatest integer less than or equal to *value*.

$FLOOR(\textit{value})$

### 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.

$\text{FNROOT}(\text{expression}, \text{variable}, \text{guess})$

**Example**

$\text{FNROOT}(M * 9.8 / 600 - 1, M, 1)$  returns  
61.2244897959.

**FRAC**

Fractional part.

$\text{FRAC}(\text{value})$

**Example**

$\text{FRAC}(23.2)$  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).

$\text{HMS} \rightarrow (\text{H.MMSSs})$

**Example**

$\text{HMS} \rightarrow (8.30)$  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).

$\rightarrow \text{HMS}(x.x)$

**Example**

$\rightarrow \text{HMS}(8.5)$  returns 8.3

**INT**

Integer part.

$\text{INT}(\text{value})$

**Example**

$\text{INT}(23.2)$  returns 23

**MANT**

Mantissa (significant digits) of *value*.

$\text{MANT}(\text{value})$

**Example**

$\text{MANT}(21.2\text{E}34)$  returns 2.12

**MAX**

Maximum. The greater of two values.

$\text{MAX}(\text{value 1}, \text{value 2})$

**Example**

$\text{MAX}(210, 25)$  returns 210

**MIN**

Minimum. The lesser of two values.

$\text{MIN}(\text{value 1}, \text{value 2})$

**Example**

$\text{MIN}(210, 25)$  returns 25

**MOD**

Modulo. The remainder of  $\text{value 1}/\text{value 2}$ .

$\text{value 1} \text{ MOD } \text{value 2}$

**Example**

$9 \text{ MOD } 4$  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,  $100(y-x)/x$ .

$\%\text{CHANGE}(x, y)$

**Example**

$\%\text{CHANGE}(20, 50)$  returns 150

**%TOTAL**

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

$\%\text{TOTAL}(x, y)$

**Example**

$\%\text{TOTAL}(20, 50)$  returns 250

**RAD→DEG**

Radians to degrees. Converts  $\text{value}$  from radians to degrees.

$\text{RAD}\rightarrow\text{DEG}(\text{value})$

**Example**

$\text{RAD}\rightarrow\text{DEG}(\pi)$  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

## Two-variable statistics

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 11-18.)

$$\text{expression1} = \text{expression2}$$

### 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.

$$\text{ISOLATE}(\text{expression}, \text{variable})$$

#### Examples

$$\text{ISOLATE}(2 * X + 8, X) \text{ returns } -4$$

$$\text{ISOLATE}(A + B * X / C, X) \text{ returns } -(A * C / B)$$

### LINEAR?

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

$$\text{LINEAR?}(\text{expression}, \text{variable})$$

#### Example

$$\text{LINEAR?}((X^2 - 1) / (X + 1), X) \text{ returns } 0$$

### 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 - .

$$\text{QUAD}(\text{expression}, \text{variable})$$

#### Example

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

## QUOTE

Encloses an expression that should not be evaluated numerically.

`QUOTE (expression)`

### Examples

`QUOTE (SIN(45))` `STOR 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` `STOR 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`

$\geq$	Greater than or equal to. Returns 1 if true, 0 if false. $value1 \geq value2$
<b>AND</b>	Compares $value1$ and $value2$ . Returns 1 if they are both non-zero, otherwise returns 0. $value1$ AND $value2$
<b>IFTE</b>	If $expression$ is true, do the $trueclause$ ; if not, do the $falseclause$ . IFTE ( $expression$ , $trueclause$ , $falseclause$ )
	<b>Example</b> IFTE ( $X > 0$ , $X^2$ , $X^3$ )
<b>NOT</b>	Returns 1 if $value$ is zero, otherwise returns 0. NOT $value$
<b>OR</b>	Returns 1 if either $value1$ or $value2$ is non-zero, otherwise returns 0. $value1$ OR $value2$
<b>XOR</b>	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.

<b>ACOT</b>	Arc cotangent. ACOT( $value$ )
<b>ACSC</b>	Arc cosecant. ACSC( $value$ )
<b>ASEC</b>	Arc secant. ASEC( $value$ )
<b>COT</b>	Cotangent: $\cos x / \sin x$ . COT( $value$ )
<b>CSC</b>	Cosecant: $1 / \sin x$ CSC( $value$ )

## SEC

Secant:  $1/\cos x$ .

SEC(value)

## Symbolic calculations

The hp 39g+ has the ability to perform symbolic calculations, for example, symbolic integration and differentiation. You can perform symbolic calculations in HOME and in the Function applet.

### 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  $\boxed{\text{ENTER}}$ , the calculator retrieves the values for  $A$  and  $B$  from memory and substitutes them in the calculation.

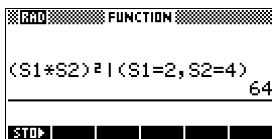
### Using formal variables

To perform symbolic calculations, for example symbolic differentiations and integrations, you need to use formal names. The hp 39g+ 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+ 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  $\boxed{\text{SHIFT}}$  CHARS. The = sign is listed in the MATH menu under Symbolic functions.)

## Symbolic calculations in the Function applet

You can perform symbolic operations in the Function applet's Symbolic view. For example, to find the derivative of a function in the Function applet'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 applet's Symbolic view" on page 11-22 for an example.

## Finding derivatives

The hp 39g+ can perform symbolic differentiation on some functions. There are two ways of using the hp 39g+ 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 applet.

### 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  
 x<sup>2</sup> ) + 2 x  
 COS ALPHA S1  
 ) )



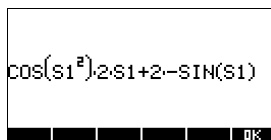
2. Evaluate the function.

ENTER



3. Show the result.

**▲** **SHOW**



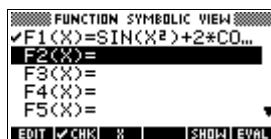
hp 39g+

## To find derivatives in the Function applet's Symbolic view

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

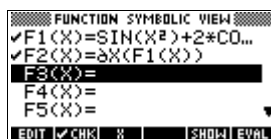
1. Access the Function applet's Symbolic view and define F1.

**SYMB** **SIN** **⊞** **x<sup>2</sup>**  
**)** **+** **2** **x** **COS**  
**⊞** **)** **⊞**



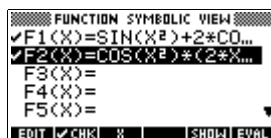
2. Define F2(x) as the derivative of F1).

**d/dx** **⊞** **(** **ALPHA**  
**F1** **(** **⊞** **)** **)**  
**⊞**



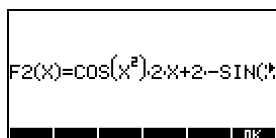
3. Select F2(x) and evaluate it.

**▲** **EVAL**



4. Press **SHOW** to display the result. *Note: Use the arrow keys to view the entire function.*

**SHOW**



hp 39g+

You could also just define

$$F1(x) = \frac{d}{dx}(\sin(x^2) + 2\cos(x)).$$

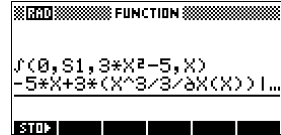
**To find the indefinite integral using formal variables**

For example, to find the indefinite integral of  $\int 3x^2 - 5 dx$  use:

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

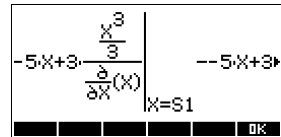
1. Enter the function.

SHIFT d/dx 0 ,  
 ALPHA S1 , 3 ×  
 ALPHA X X<sup>2</sup> - 5 ,  
 ALPHA X ) ENTER



2. Show the result format.

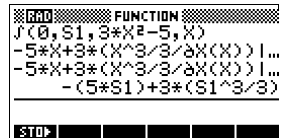
▲  
 SHOW



3. Press **OK** to close the show window.

4. Copy the result and evaluate.

COPY ENTER



hp 39g+

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

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

This result is derived 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.

```

R40:  FUNCTION
      f(0, S1, (X-2)^4, X)
      (X-2)^(4+1)/((4+1)*dX...
      (X-2)^(4+1)/((4+1)*dX...
      (S1-2)^5/5+6.4
STO>

```



# Variables and memory management

---

## Introduction

The hp 39g+ has approximately 232K of user memory. The calculator uses this memory to store variables, perform computations, and store history.

A variable is an object that you create in memory to hold data. The hp 39g+ 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**.

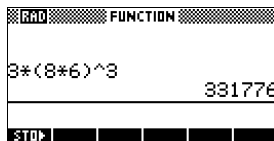


## To store the results of a calculation

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 **(** 8 **\*** 6 **)** **^** 3  
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.

$\blacktriangle$   $\boxed{\text{COPY}}$   $\boxed{\text{STORE}}$

$\boxed{\text{ALPHA}}$

A



6. Press  $\boxed{\text{ENTER}}$  to store the result.

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

2  $\boxed{\text{X}^{\text{Y}}}$  ( 5  $\boxed{\div}$  3 )

$\boxed{\text{STORE}}$   $\boxed{\text{ALPHA}}$  B

$\boxed{\text{ENTER}}$



## To recall a value

To recall a variable's value, type the name of the variable and press  $\boxed{\text{ENTER}}$ .

$\boxed{\text{ALPHA}}$  A  $\boxed{\text{ENTER}}$



## To use variables in calculations

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

65  $\boxed{+}$   $\boxed{\text{ALPHA}}$  A  $\boxed{\text{ENTER}}$



# 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.



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.*



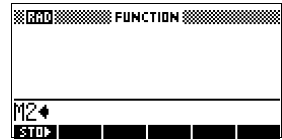
3. Move the highlight to the variables column.

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 **WRITE** 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.

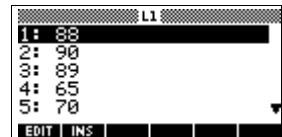
1. Display the List Catalog.

**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**





## 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, $(1,2)$ <b>SHIFT</b> Z0 or $2+3i$ <b>SHIFT</b> 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 16-20 for more information on storing graphic objects via programming commands. See "To store into a graphics variable" on page 15-5 for more information on storing graphic object via the sketch view.
Library	Aplet library variables can store applets that you have created, either by saving a copy of a standard applet, or downloading an applet from another source.
List	L0 to L9 For example, $\{1,2,3\}$ <b>SHIFT</b> L1.
Matrix	M0 to M9 can store matrices or vectors. For example, $[[1,2],[3,4]]$ <b>SHIFT</b> M0.
Modes	Modes variables store the modes settings that you can configure using <b>SHIFT</b> MODES.
Notepad	Notepad variables store notes.
Program	Program variables store programs.
Real	A to Z and $\theta$ . For example, 7.45 <b>SHIFT</b> 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-7.
Parametric	X0, Y0 to X9, Y9 (Symbolic view). See "Parametric aplet variables" on page R-8.
Polar	R0 to R9 (Symbolic view). See "Polar aplet variables" on page R-9.
Sequence	U0 to U9 (Symbolic view). See "Sequence aplet variables" on page R-10.
Solve	E0 to E9 (Symbolic view). See "Solve aplet variables" on page R-11.
Statistics	C0 to C9 (Numeric view). See "Statistics aplet variables" on page R-12.

### 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]**. (**[ENTER]** is the default setting.)



- To copy the value of the variable into the edit line, press **ENTER** and press **CE**.



## 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

- 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.

- Select the category with which you want to work and press **VIEW**. Memory Manager displays memory details of variables within the category.

**VIEW**



- To delete variables in a category:
  - Press **DEL** to delete the selected variable.
  - Press **SHIFT** *CLEAR* to delete all variables in the selected category.



# 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 mode is set to `Comma`, then separate each element and each row with a period.)

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
<b>[EDIT]</b>	Opens the highlighted matrix for editing.
<b>[NEW]</b>	Prompts for a matrix type, then opens an empty matrix with the highlighted name.
<b>[SEND]</b>	Transmits the highlighted matrix to another hp 39g+ or a disk drive. See "Sending and receiving aplets" on page 17-4.
<b>[RECV]</b>	Receives a matrix from another hp 39g+ or a disk drive. See "Sending and receiving aplets" on page 17-4.
<b>[DEL]</b>	Clears the highlighted matrix.
<b>[SHIFT]</b> <i>CLEAR</i>	Clears all matrices.
<b>[SHIFT]</b> <b>[▼]</b> or <b>[▲]</b>	Moves to the end or the beginning of the catalog.

## To create a matrix in the Matrix Catalog

1. Press  $\boxed{\text{SHIFT}} \text{MATRIX}$  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  $\boxed{\text{NEW}}$ .
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  $\boxed{\text{ENTER}}$ . (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  $\boxed{\text{GO}}$ . The  $\boxed{\text{GO}}$  menu key toggles between the following three options:
  - $\boxed{\text{GO}} \downarrow$  specifies that the cursor moves to the cell below the current cell when you press  $\boxed{\text{ENTER}}$ .
  - $\boxed{\text{GO}} \rightarrow$  specifies that the cursor moves to the cell to the right of the current cell when you press  $\boxed{\text{ENTER}}$ .
  - $\boxed{\text{GO}}$  specifies that the cursor stays in the current cell when you press  $\boxed{\text{ENTER}}$ .
6. When done, press  $\boxed{\text{SHIFT}} \text{MATRIX}$  to see the Matrix catalog, or press  $\boxed{\text{HOME}}$  to return to HOME. The matrix entries are automatically stored.

M2	1	2	3	
	1.25	56	14	
	2.99	-27	23	

EDIT INS GO+ BIG

MATRIX CATALOG		BEH
M1	1X1 REAL MATRIX	OKB
M2	2X3 REAL MATRIX	OKB
M3	1X1 REAL MATRIX	OKB
M4	1X1 REAL MATRIX	OKB
M5	1X1 REAL MATRIX	OKB

EDIT NEW SEND REC

A matrix is listed with two dimensions, even if it is  $3 \times 1$ . 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 applets, 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.

## 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
<b>EDIT</b>	Copies the highlighted element to the edit line.
<b>INS</b>	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.)
<b>GO</b>	A three-way toggle for cursor advancement in the Matrix editor. <b>GO+</b> advances to the right, <b>GO+</b> , advances downward, and <b>GO</b> does not advance at all.
<b>SIZE</b>	Switches between larger and smaller font sizes.
<b>DEL</b>	Deletes the highlighted cells, row, or column (you are prompted to make a choice).
<b>SHIFT CLEAR</b>	Clears all elements from the matrix.

Key	Meaning (Continued)
<div style="display: flex; justify-content: space-around; align-items: center;"> <span>SHIFT</span> <span>▲</span> </div> <div style="display: flex; justify-content: space-around; align-items: center;"> <span>▼</span> <span>▶</span> <span>◀</span> </div>	Moves to the first row, last row, first column, or last column respectively.

### To display a matrix

- In the Matrix catalog ( $\text{SHIFT}$   $MATRIX$ ), highlight the matrix name and press  $EDIT$ .
- In HOME, enter the name of the matrix variable and press  $ENTER$ .

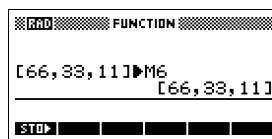
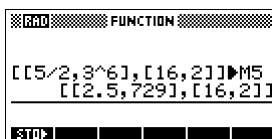
### To display one element

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** .

VAR	FUNCTION	
728	M5(1,2)	728
M5		[[2.5,728],[16,21]]
<b>STO</b>		

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**  
**0** 1 **ENTER** 2 **ENTER**  
**▼** 3 **ENTER** 4  
**ENTER**

M1	1	2		
1	1	2		
2	3	4		
<b>EDIT</b>	<b>INS</b>	<b>GO</b>	<b>BIG</b>	

2. Create the second matrix.

**SHIFT** **MATRIX** **▼**  
**NEW** **0** 5 **ENTER** 6  
**ENTER** **▼** 7 **ENTER**  
 8 **ENTER**

M2	1	2		
1	5	6		
2	7	8		
<b>EDIT</b>	<b>INS</b>	<b>GO</b>	<b>BIG</b>	



3. Add the matrices that you created.

[HOME] [ALPHA] M1  
 [+] [ALPHA] M2  
 [ENTER]

```

RAD  FUNCTION
M1+M2  [[6,8],[10,12]]
STOP
  
```

### 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, press the following keys:

[÷] 2 [ENTER]

```

RAD  FUNCTION
M1+M2  [[6,8],[10,12]]
Ans/2  [[3,4],[5,6]]
STOP
  
```

### To multiply two matrices

To multiply the two matrices M1 and M2 that you created for the previous example, press the following keys:

[ALPHA] M1 [×] [ALPHA] M2  
 [ENTER]

```

RAD  FUNCTION
Ans/2  [[3,4],[5,6]]
M1*M2  [[19,22],[43,50]]
STOP
  
```

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.

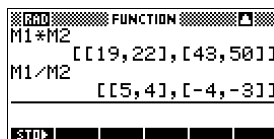
### To divide by a square matrix

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, press the following keys:

ALPHA M1  $\div$   
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 create a vector.

(SHIFT) MATRIX NEW

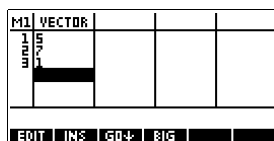
(V) ENTER



2. Create the vector of the constants in the linear system.

5 ENTER 7 ENTER

1 ENTER



3. Return to the Matrix Catalog.

(SHIFT) MATRIX

In this example, the vector you created is listed as M1.



4. Create a new matrix.

**NEW**

Select Real matrix

**OK**



5. Enter the equation coefficients.

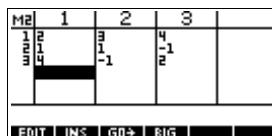
2 **ENTER** 3 **ENTER**

4 **ENTER** **▼**

1 **ENTER** 1 **ENTER**

**(-)** 1 **ENTER** 4 **ENTER**

**(-)** 1 **ENTER** 2 **ENTER**



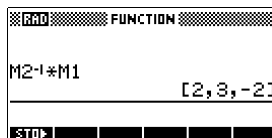
In this example, the matrix you created is listed as M2.

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**  $x^{-1}$  **×**

**ALPHA** M1 **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 13-12.

## 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 16-23 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)`

<b>DET</b>	Determinant of a square <i>matrix</i> . <code>DET(<i>matrix</i>)</code>
<b>DOT</b>	Dot Product of two arrays, <i>matrix1 matrix2</i> . <code>DOT(<i>matrix1</i>, <i>matrix2</i>)</code>
<b>EIGENVAL</b>	Displays the eigenvalues in vector form for <i>matrix</i> . <code>EIGENVAL(<i>matrix</i>)</code>
<b>EIGENVV</b>	Eigenvectors and Eigenvalues for a square <i>matrix</i> . Displays a list of two arrays. The first contains the eigenvectors and the second contains the eigenvalues. <code>EIGENVV(<i>matrix</i>)</code>
<b>IDENMAT</b>	Identity matrix. Creates a square matrix of dimension <i>size</i> × <i>size</i> whose diagonal elements are 1 and off-diagonal elements are zero. <code>IDENMAT(<i>size</i>)</code>
<b>INVERSE</b>	Inverts a square matrix (real or complex). <code>INVERSE(<i>matrix</i>)</code>
<b>LQ</b>	LQ Factorization. Factors an $m \times n$ <i>matrix</i> into three matrices: {{{ $m \times n$ lowertrapezoidal}}, { $n \times n$ orthogonal}}, { $m \times m$ permutation}}}. <code>LQ(<i>matrix</i>)</code>
<b>LSQ</b>	Least Squares. Displays the minimum norm least squares <i>matrix</i> (or <i>vector</i> ). <code>LSQ(<i>matrix1</i>, <i>matrix2</i>)</code>
<b>LU</b>	LU Decomposition. Factors a square <i>matrix</i> into three matrices: {{{lowertriangular}}, {uppertriangular}}, {permutation}}} The <i>uppertriangular</i> has ones on its diagonal. <code>LU(<i>matrix</i>)</code>
<b>MAKEMAT</b>	Make Matrix. Creates a matrix of dimension <i>rows</i> × <i>columns</i> , using <i>expression</i> to calculate each element. If <i>expression</i> 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  $3 \times 3$  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:  
 $\{[m \times m \text{ square orthogonal}], [n \times n \text{ square orthogonal}], [real]\}$ .  
`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 2x2 identity matrix  $[[1,0],[0,1]]$ .

You can also create an identity matrix using the MAKEMAT (*make matrix*) function. For example, entering MAKEMAT(I¼J,4,4) creates a 4 x 4 matrix showing the numeral 1 for all elements except zeros on the diagonal. The logical operator ¼ 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

$$\begin{aligned}x - 2y + 3z &= 14 \\2x + y - z &= -3 \\4x - 2y + 2z &= 14\end{aligned}$$

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  $3 \times 4$  real matrix in any matrix variable. M1 is used in this example.

M1	1	2	3	4
1	1	-2	3	14
2	2	1	-1	-3
3	4	-2	2	14

1  
EDIT INS GO+ BIG

You can use the RREF function to change this to reduced row echelon form, storing it in any matrix variable. M2 is used in this example.

FUNCTION	
RREF	(M1) → M2
[[1, 0, 0, 1], [0, 1, 0, -2]...	

STOP

The reduced row echelon matrix gives the solution to the linear equation in the fourth column.

M2	1	2	3	4
1	1	0	0	1
2	0	1	0	-2
3	0	0	1	3

EDIT INS GO+ BIG

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:

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

The final row of zeros in the reduced-row echelon form of the augmented matrix indicates an inconsistency.

M2	1	2	3	4
1	1	0	-.333333	4
2	0	1	-.666667	1
3	0	0	0	0

1  
EDIT INS GO+ BIG



## 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 mode 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 ( $(\text{SHIFT}) \text{LIST}$ ). You can also create and store lists—named or unnamed—in HOMEg lists

List variables are identical in behaviour to the columns C1.C0 in the Statistics applet. 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.

$(\text{SHIFT}) \text{LIST}$ .



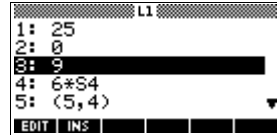
2. Highlight the list name you want to assign to the new list (L1, etc.) and press  $\text{EDIT}$  to display the List editor.



$\text{EDIT}$

- 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.



- 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
<b>EDIT</b>	Opens the highlighted list for editing.
<b>SEND</b>	Transmits the highlighted list to another hp 39g+ or a PC. See "Sending and receiving aplets" on page 17-4 for further information.
<b>RECV</b>	Receives a list from another hp 39g+ or a PC. See "Sending and receiving aplets" on page 17-4 for further information.
<b>DEL</b>	Clears the highlighted list.
<b>SHIFT</b> <i>CLEAR</i>	Clears all lists.
<b>SHIFT</b> <b>▼</b> or <b>▲</b>	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
<b>EDIT</b>	Copies the highlighted list item into the edit line.
<b>INS</b>	Inserts a new value before the highlighted item.
<b>DEL</b>	Deletes the highlighted item from the list.
<b>SHIFT</b> <i>CLEAR</i>	Clears all elements from the list.
<b>SHIFT</b> <b>▼</b> or <b>▲</b>	Moves to the end or the beginning of the list.

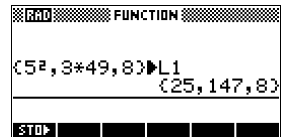
## Create a list in HOME

1. Enter the list on 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 **STORE** *listname* **ENTER**. The list variable names are L0 through L9.

This example stores the list {25,147,8} in L1.

*Note: 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**.

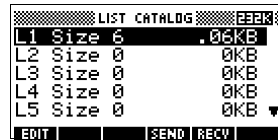
## To display one element

In HOME, enter *listname(element#)*. For example, if L2 is {3,4,5,6}, then **L2 (2)** **ENTER** returns 4.

## To edit a list

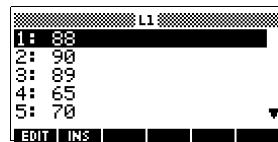
1. Open the List catalog.

**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**

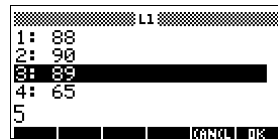


3. Press **▲** or **▼** to highlight the element you want to edit. In this example, edit the third element so that it has a value of 5.

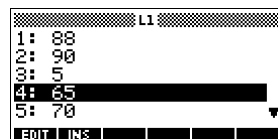
**▼** **▼** **EDIT**

**DEL** **DEL**

5



4. Press **MS**.



## 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.

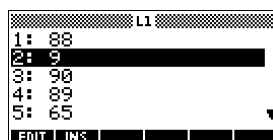


New elements are inserted above the highlighted position. In this example, an element, with the value of 9, is inserted between the first and second elements in the list.

3. Press **▼** to the insertion position, then press **INS**, and press 9.



4. Press **OK**.



## To store one element

In HOME, enter value **STORE** listname(element). For example, to store 148 as the second element in L1, type 148 **STORE** L1 (2) **ENTER**.

## Deleting lists

### To delete a list

In the List catalog, highlight the list name and press **DEL**. You are prompted to confirm that 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.

## List functions

List functions are found in the MATH menu. 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** **L** (the alpha L character key). This



highlights the List category in the left column. Press **▶** to move the cursor to the right column which contain the List functions, 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,  $\text{CONCAT}(L1.L2)$ .

Common operators like  $+$ ,  $-$ ,  $\times$ , 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 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.

$\text{CONCAT}(list1, list2)$

### Example

$\text{CONCAT}(\{1, 2, 3\}, \{4\})$  returns  $\{1, 2, 3, 4\}$ .

## $\Delta$ LIST

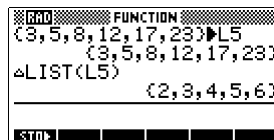
Creates a new list composed of the first differences, that is, the differences between the sequential elements in *list1*. The new list has one fewer elements than *list1*. The first differences for  $\{x_1, x_2, \dots, x_n\}$  are  $\{x_2 - x_1, \dots, x_n - x_{n-1}\}$ .

$\Delta\text{LIST}(list1)$

### 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  $\Delta$ LIST [MATH]  
 [ALPHA] L5 [ENTER]



# MAKELIST

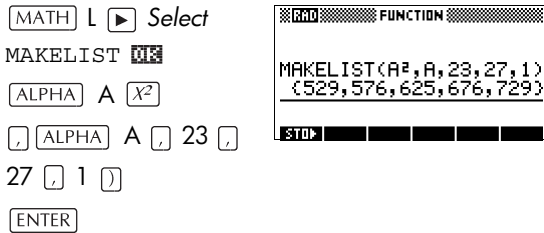
Calculates a sequence of elements for a new list. Evaluates *expression* with *variable* from *begin* to *end* values, taken at *increment* steps.

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 series of squares from 23 to 27.



# 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.

## $\Sigma$ LIST

Calculates the sum of all elements in list.

`$\Sigma$ LIST (list)`

### Example

`$\Sigma$ LIST ({2, 3, 4})` returns 9.

## SORT

Sorts elements in ascending order.

`SORT (list)`

# Finding statistical values for list elements

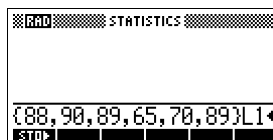
To find values such as the mean, median, maximum, and minimum values of the elements in a list, use the Statistics aplet.

### Example

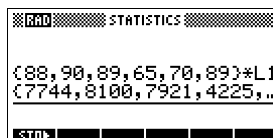
In this example, use the Statistics aplet to find the mean, median, maximum, and minimum values of the elements in the list, L1.

1. Create L1 with values 88, 90, 89, 65, 70, and 89.

`[SHIFT] { 88 [ , ] 90 [ , ]`  
`89 [ , ] 65 [ , ] 70 [ , ] 89`  
`[SHIFT] } [STO]`  
`[ALPHA] L1`



`[ENTER]`



2. In HOME, store L1 into C1. You will then be able to see the list data in the Numeric view of the Statistics applet.

L1  
  C1

STATISTICS	
(88,90,89,65,70,89)*L1	
(7744,8100,7921,4225,...	
L1→C1	
(88,90,89,65,70,89)	
STO▶	

3. Start the Statistics applet, and select 1-variable mode (press , if necessary, to display ).

Select  
 Statistics

n	C1	C2	C3	C4
1	88			
2	90			
3	89			
4	65			
5	70			
6	89			
88				
EDIT INS SORT BIG 1VAR=STATS				

*Note: Your list values are now in column 1 (C1).*

4. In the Symbolic view, define H1 (for example) as C1 (sample) and 1 (frequency).

STATISTICS SYMBOLIC VIEW	
✓H1: C1	1
H2:	1
H3:	1
H4:	1
ENTER SAMPLE	
EDIT ✓CHK C SHOW EVAL	

5. Go to the Numeric view to display calculated statistics.

1-VAR	H1		
NΣ	6		
TOTΣ	491		
MEANΣ	81.83333		
PVARΣ	105.1389		
SVARΣ	126.1667		
PSDEV	10.25373		
C			
OK			

See “One-variable” on page 8-13 for the meaning of each computed statistic.

# Notes and sketches

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## Introduction

The hp 39g+ 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  $\boxed{\text{SHIFT}} \text{NOTE}$  for the Note view.
2. Use the note editing keys shown in the table in the following section.
3. Set Alpha lock ( $\boxed{\text{H...Z}}$ ) for quick entry of letters. For lowercase Alpha lock, press  $\boxed{\text{SHIFT}} \boxed{\text{H...Z}}$ .
4. While Alpha lock is on:
  - To type a single letter of the opposite case, press  $\boxed{\text{SHIFT}}$  letter.
  - To type a single non-alpha character (such as 5 or [ ), press  $\boxed{\text{ALPHA}}$  first. (This turns off Alpha lock for one character.)

*Your work is automatically saved. Press any view key ( $\boxed{\text{NUM}}$ ,  $\boxed{\text{SYMB}}$ ,  $\boxed{\text{PLOT}}$ ,  $\boxed{\text{VIEWS}}$ ) or  $\boxed{\text{HOME}}$  to exit the Notes view.*

## Note edit keys

Key	Meaning
<b>SPACE</b>	Space key for text entry.
<b>PAGE</b>	Displays next page of a multi-page note.
<b>A...2</b>	Alpha-lock for letter entry.
<b>SHIFT</b> <b>A...2</b>	Lower-case alpha-lock for letter entry.
<b>BACKF</b>	Backspaces cursor and deletes character.
<b>DEL</b>	Deletes current character.
<b>ENTER</b>	Starts a new line.
<b>SHIFT</b> <i>CLEAR</i>	Erases the entire note.
<b>VAR</b>	Menu for entering variable names, and contents of variables.
<b>MATH</b>	Menu for entering math operations, and constants.
<b>SHIFT</b> <i>CMDS</i>	Menu for entering program commands.
<b>SHIFT</b> <i>CHARS</i>	Displays special characters. To type one, highlight it and press <b>OK</b> . To copy a character <i>without</i> closing the CHARS screen, press <b>ECHO</b> .

# 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
<b>STOP</b>	Stores the specified portion of the current sketch to a graphics variable (G1 through G0).
<b>NEWP</b>	Adds a new, blank page to the current sketch set.
<b>PAGEW</b>	Displays next sketch in the sketch set. Animates if held down.
<b>TEXT</b>	Opens the edit line to type a text label.
<b>DRAW</b>	Displays the menu-key labels for drawing.
<b>DEL</b>	Deletes the current sketch.
<b>SHIFT</b> <i>CLEAR</i>	Erases the entire sketch set.
<b>-</b>	Toggles menu key labels on and off. If menu key labels are hidden, <b>-</b> or any menu key, redisplay 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 **OR** 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**.
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

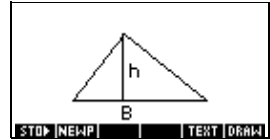
Key	Meaning
<b>DOT+</b>	Dot on. Turns pixels on as the cursor moves.
<b>DOT-</b>	Dot off. Turns pixels off as the cursor moves.
<b>LINE</b>	Draws a line from the cursor's starting position to the cursor's current position. Press <b>OK</b> when you have finished. You can draw a line at any angle.
<b>BOX</b>	Draws a box from the cursor's starting position to the cursor's current position. Press <b>OK</b> when you have finished.
<b>CIRCL</b>	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 <b>OK</b> to draw the circle.

## To label parts of a sketch

1. Press **TEXT** and type the text on the edit line. To lock the Alpha shift on, press **h...z** (for uppercase) or **SHIFT h...z** (for lowercase).

To make the label a smaller character size, turn off **BIG** before pressing **h...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 the 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 **STOP**.
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 `VAR`, `HOME`.
3. Highlight `Graphic`, then press `▶` and highlight the name of the variable (`G1`, etc.).
4. Press `VALUE` `OK` to recall the contents of the graphics variable.
5. 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 15-8.*

### To create a note in the Notepad

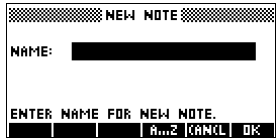
1. Display the Notepad catalog.

`(SHIFT) NOTEPAD`



2. Create a new note.

`NEW`



3. Enter a name for your note.

`NEW` MYNOTE `OK`





4. Write your note.

See "Note edit keys" on page 15-2 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
<b>EDIT</b>	Opens the selected note for editing.
<b>NEW</b>	Begins a new note, and asks for a name.
<b>SEND</b>	Transmits the selected note to another hp 39g+ or PC.
<b>RECV</b>	Receives a note being transmitted from another hp 39g+ or PC.
<b>DEL</b>	Deletes the selected note.
<b>SHIFT CLEAR</b>	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 column, then highlight the name "Assignments" in the right column.
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 `HOME` 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".

# Programming

---

## Introduction

This chapter describes how to program using the hp 39g+. 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:

**<http://www.hp.com/calculators>**

---

## The Contents of a Program

An hp 39g+ 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** *PROGRAM*.

The Program Catalog displays a list of program names. The Program Catalog contains a built-in entry called *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+ 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
<b>EDIT</b>	Opens the highlighted program for editing.
<b>NEW</b>	Prompts for a new program name, then opens an empty program.
<b>SEND</b>	Transmits the highlighted program to another hp 39g+ or to a disk drive.
<b>RECV</b>	Receives the highlighted program from another hp 39g+ or from a disk drive.
<b>RUN</b>	Runs the highlighted program.
<b>SHIFT</b> <b>▲</b> or <b>▼</b>	Moves to the beginning or end of the Program catalog.
<b>DEL</b>	Deletes the highlighted program.
<b>SHIFT</b> <i>CLEAR</i>	Deletes all programs in the program catalog.

# Creating and editing programs

## Create a new program

1. Press **[SHIFT] PROGRAM** to open the Program catalog.
2. Press **[F1] F1**.

The hp 39g+ 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 **[F1] F1**.

When you press **[F1] F1**, 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+ commands, the easiest way to enter commands is to select them from the Commands menu from the Program editor. You can also type in commands using alpha characters.


1. From the Program editor, press **[SHIFT] CMDS** to open the Program Commands menu.

**[SHIFT] CMDS**




- 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.




- Press  to paste the command into the program editor.



## Edit a program






















- Press  *PROGRAM* to open the Program catalog.



- Use the arrow keys to highlight the program you want to edit, and press . The hp 39g+ 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
	Inserts the  character at the editing point.
	Inserts space into text.
	Displays previous page of the program.
	Displays next page of the program.
 	Moves up or down one line.
 	Moves right or left one character.
	Alpha-lock for letter entry. Press  A...Z to lock lower case.
	Backspaces cursor and deletes character.
	Deletes current character.
	Starts a new line.
 <i>CLEAR</i>	Erases the entire program.
	Displays menus for selecting variable names, contents of variables, math functions, and program constants.
	
 <i>CMDS</i>	Displays menus for selecting program commands.
 <i>CHARS</i>	Displays all characters. To type one, highlight it and press  . To enter several characters in a row, use the  menu key while in the <i>CHARS</i> 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 **[F10]**

*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+ 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 hp39g+ 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. Press **[F10]** 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. Run the program.
4. Repeat the process until you correct all errors.

## Stop a program

You can stop the running of a program at any time by pressing `CANCEL` (the **[ON]** key). *Note: You may have to press it a couple of times.*

## 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] PROGRAM** to open the Program catalog.
2. Press **[F1]**.
3. Type a new file name, then choose **[F1]**.

The Program Editor opens with a new program.

4. Press **[VARS]** to open the variables menu.
5. Press **[7]** to quickly scroll to Program.
6. Press **[▶]**, then highlight the program you want to copy.
7. Press **[WRITE]**, then press **[F1]**.

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

To delete a program:

1. Press `[SHIFT] PROGRAM` 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] PROGRAM` 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.

## Customizing an aplet

You can customize 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 built-in aplet that you want to customize. For example you could customize the Function aplet or the Statistics aplet. The customized aplet inherits all the properties of the built-in aplet. Save the customized aplet with a unique name.
2. Customize the new aplet if you need to, for example by presetting axes or angle measures.
3. Develop the programs to work with your customized 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 16-10.

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 16-14 for information on the command.
5. Ensure that the customized aplet is selected, then run the menu configuration program to configure the aplet's VIEWS menu.
6. Test the customized aplet and debug the associated programs. (Refer to "Debug a program" on page 16-7).

## 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.

## Example

This example aplet is designed to demonstrate the process of customizing 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 applet

1. Open the Function applet and save it as "EXPERIMENT". The new applet appears in the Applet library.

Select  
 Function   
 EXPERIMENT



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 set the angle format.



3. Create a program called EXP.ME2 with contents as shown. This program sets the numeric view options for the applet, 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 applet, as shown. This program sets the angle mode to degrees, and sets up the initial function that the applet 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.

- Open the Program catalog and create a program named "EXP.SV". Include the following code in the program.

Each entry line after the command SETVIEWS is a trio that consists of a VIEWS menu text line (a space indicates none), a program

```

EXP.SV PROGRAM
"Entry1"; "EXP.ME1"; "My
Entry2"; "EXP.ME2"; 3; "
"; "EXP.SV"; 0; "
"; "EXP.ANG"; 0; "START";
"EXP.S"; 7;
STOP [SPACE] | | Run2 [BKSP]

```

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 applet when the applet is transferred.

```
SETVIEWS " "; " "; 18;
```

Sets the first menu option to be "Auto scale". This is the fourth standard Function applet 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 16-14.

```
"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 applet. 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 applet, but it allows users to modify the applet'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:



PROGRAM CATALOG	
EXP.SV	.11KB
EXP.S	.07KB
EXP.ANG	.15KB
EXP.ME2	.12KB
EXP.ME1	.13KB

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+. You can enter these commands in your program by typing them or by accessing them from the Commands menu.

# Aplet commands

## CHECK

Checks (selects) the corresponding function in the current applet. For example, Check 3 would check F3 if the current applet 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 applet and makes it the current applet.  
*Note: Quotes are needed if the name contains spaces or other special characters.*

SELECT *appletname*:

## SETVIEWS

The SETVIEWS command is used to define entries in the VIEWS menu for applets that you customize. See “Customizing an applet” on page 16-9 for an example of using the SETVIEWS command.

When you use the SETVIEWS command, the applet’s standard VIEWS menu is deleted and the customized menu is used in its place. You only need to apply the command to an applet once. The VIEWS 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 applet’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 applet’s VIEWS menu remain with the applet. You need to invoke the command on the applet again to change the VIEWS menu.
- All the programs that are called from the VIEWS menu are transferred when the applet 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 applet, but are not called as menu options. For example, these can be sub-programs that menu



options use, or the program that defines the applet'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 applet starts. This program typically sets up the applet's initial configuration. The START option on the menu is also useful for resetting the applet.

### **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 applet***

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 applet and transferred whenever the applet is transmitted. Typically, you do this if you want to transfer the Setviews program with the applet, 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 applet. This is useful for setting up a program to configure the applet. Users can select the Start item from the VIEWS menu to reset the applet if they change configurations.

You can also define a menu item called "Reset" which is auto-run if the user chooses the  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 applet's SETVIEWS command are transferred when the applet is transmitted.

### ***ViewNumber***

*ViewNumber* 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 applet's standard VIEWS 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 applet.*

### ***View numbers***

The Function applet views are numbered as follows:

0	HOME	11	List Catalog
1	Plot	12	Matrix Catalog
2	Symbolic	13	Notepad Catalog
3	Numeric	14	Program 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	Applet Catalog	21	Trig

### **UNCHECK**

Unchecks (unselects) the corresponding function in the current applet. For example, Uncheck 3 would uncheck F3 if the current applet 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-clause1 THEN true-clause1 END  
IF test-clause2 THEN true-clause2 END  
.  
.  
.  
IF test-clausen THEN true-clausen END  
END
```

When CASE is executed, *test-clause*<sub>1</sub> is evaluated. If the test is true, *true-clause*<sub>1</sub> is executed, and execution skips to END. If *test-clause*<sub>1</sub> is false, execution proceeds to *test-clause*<sub>2</sub>. 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+ 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 applet's Xmin, Xmax, Ymin, and Ymax values. *The following examples assume the hp 39g+ default settings with the Function applet as the current applet.*

### 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_measurement;  
end_angle_measurement;
```

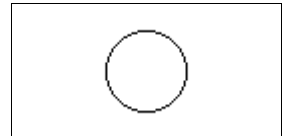
#### Example

```
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 diagonally opposite corners  $(x1,y1)$  and  $(x2,y2)$ .

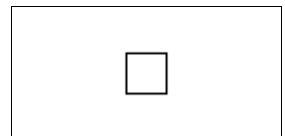
```
BOX x1;y1;x2;y2:
```

#### Example

```
BOX -1;-1;1;1:
```

```
FREEZE:
```

Draws a box, lower corner at  $(-1,-1)$ , upper corner at  $(1,1)$



<b>ERASE</b>	Clears the display <code>ERASE :</code>
<b>FREEZE</b>	Halts the program, freezing the current display. Execution resumes when any key is pressed.
<b>LINE</b>	Draws a line from $(x1, y1)$ to $(x2, y2)$ . <code>LINE x1;y1;x2;y2:</code>
<b>PIXOFF</b>	Turns off the pixel at the specified coordinates $(x,y)$ . <code>PIXOFF x;y:</code>
<b>PIXON</b>	Turns on the pixel at the specified coordinates $(x,y)$ . <code>PIXON x;y:</code>
<b>TLINE</b>	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. <code>TLINE x1;y1;x2;y2:</code>

### 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`.

<b>DISPLAY→</b>	Stores the current display in <i>graphicname</i> . <code>DISPLAY→ graphicname:</code>
-----------------	------------------------------------------------------------------------------------------

- 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+ 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 hp allow a program to execute a routine repeatedly. The hp 39g+ 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 command 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 command 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,...,valuen] ; column_number :
```

**ADDRROW**

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*.

```
ADDRROW name ; [value1,..., valuen] ; row_number :
```

<b>DELCOL</b>	Delete Column. Deletes the specified column from the specified matrix.  <code>DELCOL name ; column_number :</code>
<b>DELROW</b>	Delete Row. Deletes the specified row from the specified matrix.  <code>DELROW name ; row_number :</code>
<b>EDITMAT</b>	Starts the Matrix Editor and displays the specified matrix. If used in programming, returns to the program when user presses  .
<b>RANDMAT</b>	Creates random matrix with a specified number of rows and columns and stores the result in <i>name</i> ( <i>name</i> must be M0 . . M9). The entries will be integers ranging from -9 to 9.  <code>RANDMAT name ; rows ; columns :</code>
<b>REDIM</b>	Redimensions the specified matrix or vector to <i>size</i> . For a matrix, <i>size</i> is a list of two integers $\{n1, n2\}$ . For a vector, <i>size</i> is a list containing one integer $\{n\}$ .  <code>REDIM name ; size :</code>
<b>REPLACE</b>	Replaces portion of a matrix or vector stored in <i>name</i> with an object starting at position <i>start</i> . <i>start</i> for a matrix is a list containing two numbers; for a vector, it is a single number. Replace also works with lists and graphics.  <code>REPLACE name ; start ; object :</code>
<b>SCALE</b>	Multiplies the specified <i>row_number</i> of the specified matrix by <i>value</i> .  <code>SCALE name ; value ; rownumber :</code>
<b>SCALEADD</b>	Multiplies the row of the matrix <i>name</i> by <i>value</i> , then adds this result to the second specified row.  <code>SCALEADD name ; value ; row1 ; row2 :</code>

**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.

**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

**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 ; option1 ;  
option2 ; ...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*<sub>1</sub>...*option* <sub>$n$</sub>  are the options listed in the choose box.

### Example

```
3 ► A:CHOOSE A ;  
"COMIC STRIPS" ;  
"DILBERT" ;  
"CALVIN&HOBBES" ;  
"BLONDIE" ;
```



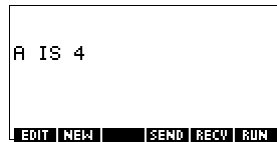
## DISP

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 .

EDITMAT *matrixname* :

The EDITMAT command can also be used to create matrices.

1. Press  CMD5  ►  .
2. Press  M 1, and then press .

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  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  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: "  $\pi * A^2$  :
```

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 " "  $\pi * A^2$  :
```

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 analyzing one-variable and two-variable statistical data.

## Stat-One commands

### DO1VSTATS

Calculates STATS using *datasetname* and stores the results in the corresponding variables:  $N\Sigma$ ,  $Tot\Sigma$ ,  $Mean\Sigma$ ,  $PVar\Sigma$ ,  $SVar\Sigma$ ,  $PSDev$ ,  $SSDev$ ,  $Min\Sigma$ ,  $Q1$ , Median,  $Q3$ , and  $Max\Sigma$ . *Datasetname* can be H1, H2, ..., or H5. *Datasetname* must include at least two data points.

DO1VSTATS *datasetname* :

### SETFREQ

Sets *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

Sets *datasetname* sample according to *column*. *Datasetname* can be H1–H5, and *column* can be C0–C9.

SETSAMPLE *datasetname* ; *column* :

## Stat-Two commands

### DO2VSTATS

Calculates STATS using *datasetname* and stores the results in corresponding variables:  $MeanX$ ,  $\Sigma X$ ,  $\Sigma X^2$ ,  $MeanY$ ,  $\Sigma Y$ ,  $\Sigma Y^2$ ,  $\Sigma XY$ ,  $Corr$ ,  $PCov$ ,  $SCov$ , and  $RELERR$ . *Datasetname* can be S1, S2, ..., or S5. *Datasetname* must include at least two pairs of data points.

DO2VSTATS *datasetname* :

### SETDEPEND

Sets *datasetname* dependent *column*. *Datasetname* can be S1, S2, ..., or S5 and *column* can be C0–C9.

SETDEPEND *datasetname* ; *column* :

### SETINDEP

Sets *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+ 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 ( $\boxed{\text{VARS}}$ ) to retrieve either Home variables or aplet variables. See “The VARS menu” on page 12-4. 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

### **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

$n_1 \blacktriangleright \text{Nmin}$

$n_2 \blacktriangleright \text{Nmax}$

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  $\blacktriangleright$  Recenter— to turn recenter on (default).

0  $\blacktriangleright$  Recenter—to turn recenter off.

## **Root**

*Function*

Contains the last value found by the Root function in the Plot-FCN menu.

## **S1mark–S5mark**

*Statistics*

Sets the mark to use for scatter plots.

From Plot Setup for two-variable statistics, S1mark-S5mark, then choose a mark.

or

In a program, type

$n \blacktriangleright \text{S1mark}$

where  $n$  is 1, 2, 3, . . . 5

## **SeqPlot**

*Sequence*

Enables you to choose types of sequence plot: Stairstep or Cobweb.

From Plot Setup, select SeqPlot, then choose Stairstep or Cobweb.

or

In a program, type

1  $\blacktriangleright$  SeqPlot—for Stairstep.

2  $\blacktriangleright$  SeqPlot—for Cobweb.

## **Simult**

*Function*

*Parametric*

*Polar*

*Sequence*

Enables you to choose 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*

Enables you to choose types 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 Box-and-Whisker.

## **Umin/Umax**

*Polar*

Sets 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*

Sets 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*

Sets 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 the 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*

Sets the step size for the 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*

Sets the horizontal coordinate of the crosshairs. Only works with TRACE off.

In a program, type

$n$  ► Xcross

## **Ycross**

*All Aplets*

Sets the vertical coordinate of the crosshairs. Only works with TRACE off.

In a program, type

$n$  ► Ycross

## **Xtick**

*All Aplets*

Sets 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*

Sets 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*

Sets 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

`n1 ▶ Xmin`

`n2 ▶ Xmax`

where  $n_2 > n_1$

## **Ymin / Ymax**

*All Aplets*

Sets 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

`n1 ▶ Ymin`

`n2 ▶ 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

$n \blacktriangleright$  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

$n \blacktriangleright$  YZOOM

## Symbolic-view variables

**Angle**  
*All Aplets*

Sets the angle mode.  
From Symbolic Setup, choose Degrees, Radians, or Grads for angle measure.  
or  
In a program, type

- 1  $\blacktriangleright$  Angle —for Degrees.
- 2  $\blacktriangleright$  Angle —for Radians.
- 3  $\blacktriangleright$  Angle —for Grads.

**F1...F9, F0**  
*Function*

Can contain any expression. Independent variable is X.

**Example**

'SIN (X) '  $\blacktriangleright$  F1 (X)

You must put single quotes around an 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) '  $\blacktriangleright$  Y1 (T) : '2\*SIN (6\*T) '  $\blacktriangleright$   
X1 (T)

## **R1...R9, R0**

*Polar*

Can contain any expression. Independent variable is  $\theta$ .

### **Example**

'2\*SIN(2\* $\theta$ )' ► R1( $\theta$ )

## **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*

Sets 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 numbers or names 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 applet variables control the Numeric view. The value of the variable applies to the current applet 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 ► Cn

where  $n = 0, 1, 2, 3 \dots 9$

### **Digits**

*All Applets*

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 the Solve applet, the value of Digits takes effect only after the current applet is saved with a new name. Until then, HDigit is in effect.

### **Format**

*All Applets*

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 number (or its name) into the variable Format.

1 Standard

2 Fixed

3 Scientific

4 Engineering

Except in the Solve applet, the value of `Format` takes effect only after the current applet is saved with a new name. Until then, `HFormat` is in effect.

### Example

Scientific ► `Format`

or

3 ► `Format`

## NumCol

*All Aplets except  
Statistics applet*

Sets the column to be highlighted 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*

Enables you to choose the font size in Numeric view.

Does not appear in the Num Setup input form.

Corresponds to the  key in Numeric view.

In a program, type

0 ► `NumFont` for small (default).

1 ► `NumFont` for big.

## NumIndep

*Function  
Parametric  
Polar  
Sequence*

Specifies the list of independent values to be used by Build Your Own Table.

In a program, type

`LIST` ► `NumIndep`

## NumRow

*All Aplets except  
Statistics applet*

Sets the row to be highlighted in Numeric view.

In a program, type

`n` ► `NumRow`

where  $n > 0$

## NumStart

*Function  
Parametric  
Polar  
Sequence*

Sets 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*

Sets 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

$n \blacktriangleright$  NumStep

where  $n > 0$

## NumType

*Function*

*Parametric*

*Polar*

*Sequence*

Sets the table format.

From Num Setup, choose Automatic or Build Your Own.

or

In a program, type

0  $\blacktriangleright$  NumType for Build Your Own.

1  $\blacktriangleright$  NumType for Automatic (default).

## NumZoom

*Function*

*Parametric*

*Polar*

*Sequence*

Sets the zoom factor in the Numeric view.

From Num Setup, type in a value for NUMZOOM.

or



In a program, type

$n \blacktriangleright$  NumZoom

where  $n > 0$

## StatMode

*Statistics*

Enables you to choose between 1-variable and 2-variable statistics in the Statistics aplet. Does not appear in the Plot Setup input form. Corresponds to the  and  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  $\blacktriangleright$  StatMode

or

1  $\blacktriangleright$  StatMode

## Note variables

The following applet variable is available in Note view.

### NoteText

*All Aplets*

Use NoteText to recall text previously entered in Note view.

## Sketch variables

The following applet variables are available in Sketch view.

### Page

*All Aplets*

Sets 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*

Sets a number 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

## Extending aplets

---

Aplets are the application environments where you explore different classes of mathematical operations.

You can extend the capability of the hp 39g+ 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 Hewlett-Packard's Calculator web site.
- Program new aplets. See chapter 16, 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.

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.

### Example

This example demonstrates how to create a new aplet by saving a copy of the built-in Solve aplet. The new aplet is saved under the name "TRIANGLES" contains the formulas commonly used in calculations involving right-angled triangles.

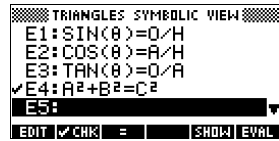
1. Open the Solve aplet and save it under the new name.

[APLET] Solve  
 [SAVE] [ALPHA]  
 TRIANGLES  
 [ENTER] [START]



2. Enter the four formulas:

[SIN] [ALPHA]  $\theta$   
 [)] [=] [ALPHA]  $\circ$   
 [÷] [ALPHA] H [ENTER]  
 [COS] [ALPHA]  $\theta$  [)] [=]  
 [ALPHA] A [÷]  
 [ALPHA] H [ENTER]  
 [TAN] [ALPHA]  $\theta$  [)] [=]  
 [ALPHA]  $\circ$  [÷] [ALPHA] A [ENTER]  
 [ALPHA] A [X<sup>2</sup>] [+] [ALPHA] B [X<sup>2</sup>]  
 [=] [ALPHA] C [X<sup>2</sup>] [ENTER]



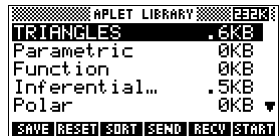
3. Decide whether you want the aplet to operate in Degrees, Radians, or Grads.

[SHIFT] MODES [CHOOSE]  
 Degrees  
 [OK]



4. View the Aplet Library. The “TRIANGLES” aplet is listed in the Aplet Library.

[APLET]  
 The Solve aplet can now  
 be reset and used for  
 other problems.



## Using a customized applet

To use the “Triangles” applet, 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  $35^\circ$  with the horizontal and extends 5 metres up the wall.

1. Select the applet.

TRIANGLES

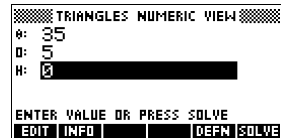


2. Choose the sine formula in E1.

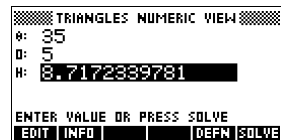


3. Change to the Numeric view and enter the known values.

35   
5



4. Solve for the missing value.



The length of the ladder is approximately 8.72 metres

## Resetting an applet

Resetting an applet clears all data and resets all default settings.

To reset an applet, open the Library, select the applet and press .

You can only reset an applet that is based on a built-in applet if the programmer who created it has provided a Reset option.

## Annotating an applet with notes

The Note view (**[SHIFT]NOTE**) attaches a note to the current applet. See Chapter 15, “Notes and sketches”.

## Annotating an applet with sketches

The Sketch view (**[SHIFT]SKETCH**) attaches a picture to the current applet. See chapter 15, “Notes and sketches”.

### HINT

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Notes and sketches that you attach to an applet become part of the applet. When you transfer the applet to another calculator, the associated note and sketch are transferred as well.

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## Downloading e-lessons from the web

In addition to the standard applets that come with the calculator, you can download applets from the world wide web. For example, Hewlett-Packard’s Calculators web site contains applets that demonstrate certain mathematical concepts. Note that you need the Graphing Calculator Connectivity Kit in order to load applets from a PC.

Hewlett-Packard’s Calculators web site can be found at:

**<http://www.hp.com/calculators>**

## Sending and receiving applets

A convenient way to distribute or share problems in class and to turn in homework is to transmit (copy) applets directly from one hp 39g+ to another. This takes place via the infrared port.

You can also send applets to, and receive applets from, a remote storage device (applet disk drive or computer). This takes place via a cable connection and requires an applet disk drive or special software running on a PC (such as the PC Connectivity Kit).



## To transmit an aplet

1. Connect the PC or aplet disk drive 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, and press **DEL**. To delete all custom aplets, press **SHIFT CLEAR**.

# Reference information

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## 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 <code>DISP expression; line#</code> .
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 <code>CROSS(matrix1, matrix2)</code> .
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 mode is set to 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 mode is set to 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 <i>menu-key labels</i> 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 applet.
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 applet.
variable	The name of a number, list, matrix, note, or graphic that is stored in memory. Use <b>STO</b> to store and use <b>VAR</b> to retrieve.
vector	A one-dimensional array of values separated by commas (periods if the Decimal Mark mode is set to 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.



## Resetting the hp 39g+

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, “To erase all memory and reset defaults”.

### To reset using the keyboard


Press and hold the  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 . If necessary, press  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  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+ 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-4), press and hold the **ON** key for 10 seconds, and then put the batteries back in. Press the **ON** key.

## 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.

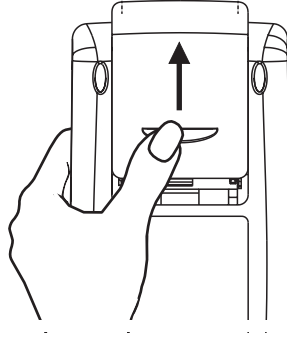
## Batteries

The calculator uses 3 AAA batteries as main power and a CR2032 lithium battery for memory backup.

Before using the calculator, please install the batteries according to the following procedure.

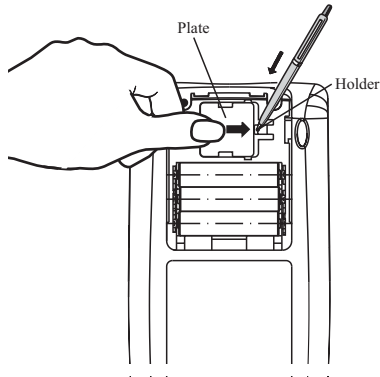
## To install the main batteries

- Slide up the battery compartment cover as illustrated.
- Insert 3 new AAA batteries into the main compartment. Make sure each battery is inserted in the indicated direction.



## To install the backup battery

- Press down the holder. Push the plate to the shown direction and lift it.



- Insert a new CR2032 lithium battery. Make sure its positive (+) side is facing up.
- Replace the plate and push it to the original place.

After installing the batteries, press **ON** to turn the power on.

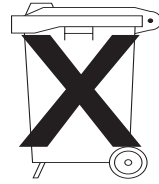
**Warning:** When the low battery icon is displayed, you need to replace the batteries as soon as possible. However, avoid removing the backup battery and main batteries at the same time to avoid data lost.

## 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 weggooien maar inleveren als KCA.



# Variables

## Home variables

The home variables are:

Category	Available name
Complex	Z1...Z9, Z0
Graphic	G1...G9, G0
Library	Function Parametric Polar Sequence Solve Statistics <i>User-named</i>
List	L1...L9, L0
Matrix	M1...M9, M0
Modes	Ans Date HAngle HDigits HFormat Ierr Time
Notepad	<i>User-named</i>
Program	Editline <i>User-named</i>



Category	Available name (Continued)
Real	A...Z, $\theta$

## Function aplet variables

The function aplet variables are:

Category	Available name		
Plot	Axes	Xcross	
	Connect	Ycross	
	Coord	Xtick	
	FastRes	Ytick	
	Grid	Xmin	
	Indep	Xmax	
	InvCross	Ymin	
	Labels	Ymax	
	Recenter	Xzoom	
	Simult	Yzoom	
	Tracing		
	Plot-FCN	Area	Root
		Extremum	Slope
Isect			
Symbolic	Angle	F6	
	F1	F7	
	F2	F8	
	F3	F9	
	F4	F0	
	F5		
Numeric	Digits	NumRow	
	Format	NumStart	
	NumCol	NumStep	
	NumFont	NumType	
	NumIndep	NumZoom	
Note	NoteText		
Sketch	Page	PageNum	

# Parametric applet variables

The parametric applet variables are:

Category	Available name		
Plot	Axes	Tracing	
	Connect	Tstep	
	Coord	Xcross	
	Grid	Ycross	
	Indep	Xtick	
	InvCross	Ytick	
	Labels	Xmin	
	Recenter	Xmax	
	Simult	Ymin	
	Tmin	Ymax	
	Tmax	Xzoom	
		Yzoom	
	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 applet variables

The polar applet variables are:

Category	Available names	
Plot	Axes	
	Connect	Xcross
	Coord	Ycross
	Grid	Xtick
	Indep	Ytick
	InvCross	Xmin
	Labels	Xmax
	Recenter	Ymin
	Simult	Ymax
	Umin	Xzoom
	Umax	Yzoom
	$\theta$ step	
	Tracing	
	Symbolic	Angle
R1		R7
R2		R8
R3		R9
R4		R0
R5		
Numeric	Digits	NumRow
	Format	NumStart
	NumCol	NumStep
	NumFont	NumType
	NumIndep	NumZoom
Note	NoteText	
Sketch	Page	PageNum

# Sequence applet variables

The sequence applet variables are:

Category	Available name	
Plot	Axes	Tracing
	Coord	Xcross
	Grid	Ycross
	Indep	Xtick
	InvCross	Ytick
	Labels	Xmin
	Nmin	Xmax
	Nmax	Ymin
	Recenter	Ymax
	SeqPlot	Xzoom
	Simult	Yzoom
	Symbolic	Angle
U1		U7
U2		U8
U3		U9
U4		U0
U5		
Numeric	Digits	NumRow
	Format	NumStart
	NumCol	NumStep
	NumFont	NumType
	NumIndep	NumZoom
Note	NoteText	
Sketch	Page	PageNum

# Solve applet variables

The solve applet variables are:

Category	Available name	
Plot	Axes	Xcross
	Connect	Ycross
	Coord	Xtick
	FastRes	Ytick
	Grid	Xmin
	Indep	Xmax
	InvCross	Ymin
	Labels	Ymax
	Recenter	Xzoom
	Tracing	Yzoom
Symbolic	Angle	E6
	E1	E7
	E2	E8
	E3	E9
	E4	E0
	E5	
Numeric	Digits	NumCol
	Format	NumRow
Note	NoteText	
Sketch	Page	PageNum

# Statistics applet variables

The statistics applet variables are:

Category	Available name	
Plot	Axes	S4mark
	Connect	S5mark
	Coord	StatPlot
	Grid	Tracing
	Hmin	Xcross
	Hmax	Ycross
	Hwidth	Xtick
	Indep	Ytick
	InvCross	Xmin
	Labels	Xmax
	Recenter	Ymin
	S1mark	Ymax
	S2mark	Xzoom
	S3mark	Yzoom
	Symbolic	Angle
S1fit		S4fit
S2fit		S5fit
Numeric	C0, ... C9	NumFont
	Digits	NumRow
	Format	StatMode
	NumCol	
Stat-One	Max $\Sigma$	Q3
	Mean $\Sigma$	PSDev
	Median	SSDev
	Min $\Sigma$	PVar $\Sigma$
	N $\Sigma$	SVar $\Sigma$
	Q1	Tot $\Sigma$
Stat-Two	Corr	$\Sigma X$
	Cov	$\Sigma X^2$
	Fit	$\Sigma XY$
	MeanX	$\Sigma Y$
	MeanY	$\Sigma Y^2$
	RelErr	
Note	NoteText	
Sketch	Page	PageNum

# MATH menu categories

## Math functions

The math functions are:

Category	Available name
Calculus	$\partial$ $\int$ TAYLOR
Complex	ARG CONJ IM RE
Constant	e i MAXREAL MINREAL $\pi$
Hyperb.	ACOSH ASINH ATANH COSH SINH TANH ALOG EXP EXPM1 LNPI
List	CONCAT $\Delta$ LIST MAKELIST $\pi$ LIST POS REVERSE SIZE $\Sigma$ LIST SORT
Loop	ITERATE RECURSE $\Sigma$

Category	Available name (Continued)		
Matrix	COLNORM	QR	
	COND	RANK	
	CROSS	ROWNORM	
	DET	RREF	
	DOT	SCHUR	
	EIGENVAL	SIZE	
	EIGENVV	SPECNORM	
	IDENMAT	SPECRAD	
	INVERSE	SVD	
	LQ	SVL	
	LSQ	TRACE	
	LU	TRN	
	MAKEMAT		
	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?		



Category	Available name (Continued)	
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	DISPLAY→ →DISPLAY →GROB GROBNOT GROBOR GROBXOR MAKEGROB PLOT→ →PLOT REPLACE SUB ZEROGROB
Loop	FOR = TO STEP END DO UNTIL END WHILE REPEAT END BREAK
Matrix	ADDCOL ADDRROW 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

# Status messages

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) applets (using <code>SHIFT MEMORY</code> ).
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 <code> </code> (where) function attempted to assign a value to the variable of integration or summation index.

<b>Message</b>	<b>Meaning (Continued)</b>
No Equations Checked	You must enter and check an equation (Symbolic view) before evaluating this function.
(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 <b>SHIFT</b> <i>MEMORY</i> ).

# Limiting Warranty

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hp 39g+ Graphing Calculator; Warranty period: 12 months

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Brazil	Sao Paulo 3747-7799; ROTC 0-800-15775 1
Mexico	Mx City 5258-9922; ROTC 01-800-472-6684
Venezuela	0800-4746-8368
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Columbia	9-800-114726
Peru	0-800-10111
Central America & Caribbean	1-800-711-2884
Guatemala	1-800-999-5105
Puerto Rico	1-877-232-0589
Costa Rica	0-800-011-0524

**N.America**

<b>Country :</b>	<b>Telephone numbers</b>
U.S.	1 800-HP INVENT
Canada	(905) 206-4663 or 800- HP INVENT

ROTC = Rest of the country



## Regulatory information

This section contains information that shows how the hp 39g+ 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 39g+ 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 ICES-003. Cet appareil numérique de la classe B est conforme à la norme NMB-003 du Canada.

### Japan

この装置は、情報処理装置等電波障害自主規制協議会 (VCCI) の基準に基づく第二情報技術装置です。この装置は、家庭環境で使用することを目的としていますが、この装置がラジオやテレビジョン受信機に近接して使用されると、受信障害を引き起こすことがあります。取扱説明書に従って正しい取り扱いをしてください。



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