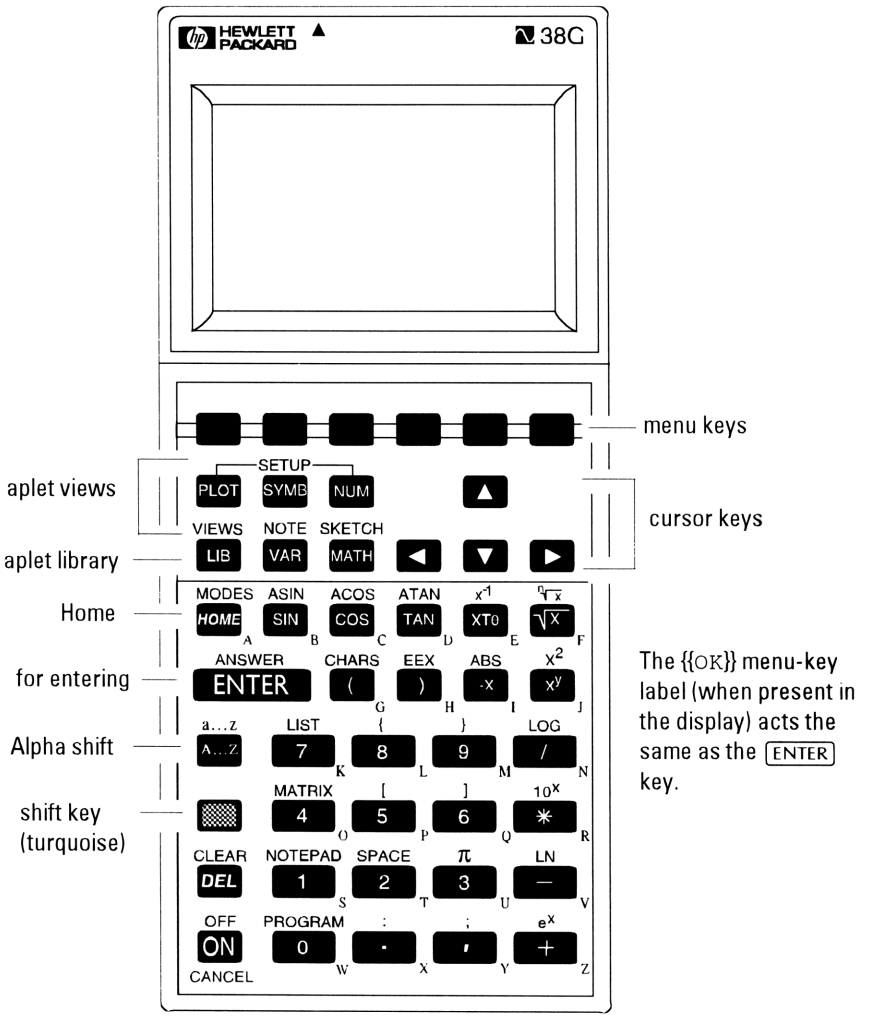
HEWLETT®
PACKARD

# User's Guide

# HP 38G




## Key Conventions--Examples:

**[ANSWER]** Means press the shift key followed by the ENTER key.

**A** Means press the Alpha-shift key followed by the HOME key.

# HP 38G Graphing Calculator
# User's Guide


HP Part No. F1200-90013

Printed in Singapore

## Notice

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**Hewlett-Packard Co.**
**Asia-Pacific Personal Computer Division**
**72 Bendemeer Rd.**
**#01/01-#07-01**
**Singapore 1233**

## Acknowledgments

Hewlett-Packard gratefully acknowledges the members of the Education Advisory Committee (Walter Bitz, Tom Dick, Mark Howell, Alice Kaseberg, Jim McManus, Carla Randall, Alison Warr, and Wade White) for their assistance in the development of this product.

## Edition History

Edition 1.....May 1995

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**Plotting and Exploring Functions**



**Solve**

**Statistics**



**Using Matrices**



**Using Lists**

**Programming**



**Reference Information**

# 1

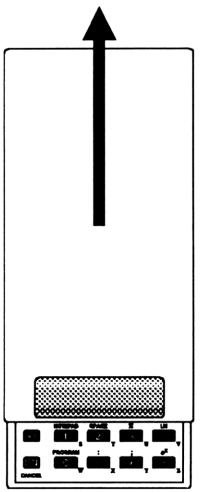
# Getting Started

Read this chapter first! It will get you started using your HP 38G, from turning it on to running aplets.

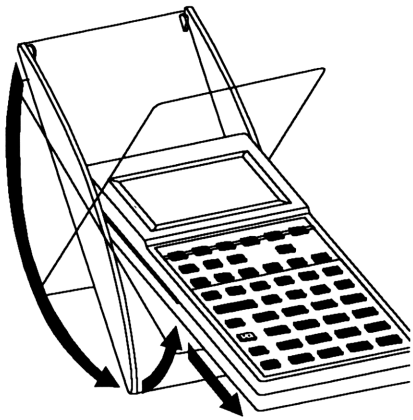
## Starting Out

**The Cover**

The protective cover swivels to provide a base for the calculator. Be sure to protect the display by replacing the cover before transporting the calculator. Slide the cover gently so as not to hit the keys.



First push the cover away from you until it catches.



Then swivel the cover to the back and slide it towards you.

**ON/CANCEL**

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

**OFF**

Pressing ■ ON (that is, ■ [OFF]) turns the calculator off.

**Demo**

To see a demonstration of the HP 38G's features, type DEMO into the edit line in Home. (Press [HOME] [A...Z]D [A...Z]E [A...Z]M [A...Z]O [ENTER].) To stop the demo, press any key.

**Home**

Home is the calculator's home base. If you want to do calculations, or you want to quit the current activity (such as an aplet, a program, or an editor), press [HOME].

**Power**

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

If you see the ((•)) annunciator or the `Low Bat` message, then the calculator needs fresh batteries. See chapter 9.

# The Keyboard

**Shifted Keystrokes**
■

The ■ (*shift*) key is a shifted keystroke that accesses the operation printed in turquoise above a key. For instance, to access the Modes screen, press ■, then [HOME]. (You do not need to hold down the ■.) This is depicted in this manual as "press ■ [MODES]."

To cancel a shift, press ■ again.

**Alpha Shift**
[A...Z]

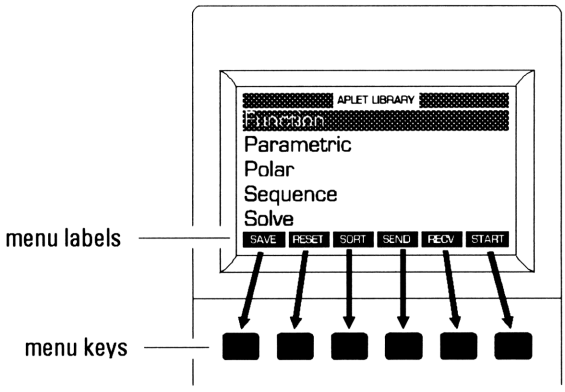
The alphabetic keys are also shifted keystrokes. For instance, to type **z**, press [A...Z] [+]. (The letters are printed in light green to the lower right of each key.)

To cancel Alpha, press [A...Z] again.

- For a lowercase letter, press ■ [A...Z].
- For a string of letters, hold down [A...Z] while typing.

**Menu Keys**

You can press [LIB] to see this screen:

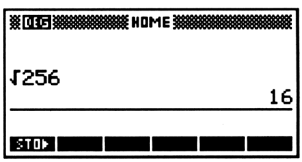



- The top-row keys are called *menu keys* because their meanings depend on the context—that's why their tops are blank.
- The bottom line of the display shows the labels for the menu keys' current meanings. {{SAVE}} is the label for the first menu key in this picture. "Press {{SAVE}}" means to press the leftmost top-row key.

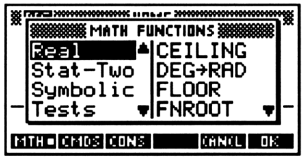
**Math Keys**

Home (press [HOME]) is the place to do calculations.

- **Keyboard keys.** The most common arithmetic operations are on the keyboard, such as the arithmetic (like [+]) and trigonometric (like [SIN]) functions. Press [ENTER] to complete the operation : [√x] **256** [ENTER] displays **16** .



- **MATH menu.** The [MATH] menu is a comprehensive menu list of math operations that do not appear on the keyboard. It also includes categories for all other functions *and* programmable commands. 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 to the item list ([▶], [◀]).

  Press {{CANCL}} to cancel the MATH menu.

  Pressing {{CMDS}} displays the list of Program Commands. Pressing {{CONS}} displays the list of Program Constants. Pressing {{MTH}} displays the list of Math Functions.

**Keys for Entry and Editing**

| Key | Meaning |
|---|---|
| [ON] (CANCEL) | Pressing [ON] while the calculator is on *cancels* the current operation. Pressing ■ first turns the calculator off. |
| ■ *(shift)* | Accesses the function printed in turquoise color above a key. |
| [HOME] | Home base for calculations. |
| [A...Z] | Alphabetic entry—press before a letter key. |
| [ENTER] | Enters an input or executes an operation. In calculations, [ENTER] acts like "=" When {{OK}} is present as a menu key, [ENTER] acts the same as {{OK}}. |
| [-x] | Starts a negative number. To enter −5, press [-x] **5**. |
| **[EEX]** | Enters an exponent of 10. To enter $5\times10^9$, you press **5** ■ **[EEX] 9**. This appears as `5E9` or, after pressing [ENTER], `5000000000`. |
| [X,T,θ] | Independent variable key. Types X, T, Θ, or N into the display, depending on the current context. |
| [DEL] | Delete key. Backspaces if at the end of the line. |
| ■ **[CLEAR]** | Clear key. Clears all data on the screen except settings, which return to their default values. |
| [◀] [▶] [▲] [▼] | Cursor-movement (navigation) keys. Press ■ first to move *far*. |
| ■ **[CHARS]** | Displays all available characters. To type one, highlight it and press {{OK}}. |

**Inactive Keys**

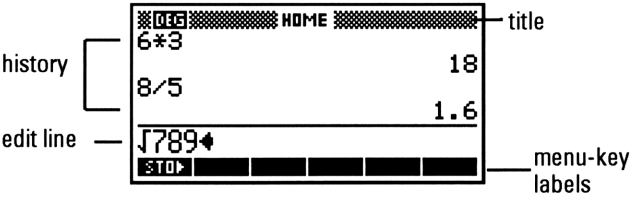
If you press a key that does not operate in the current context, a warning symbol like this ⚠ appears. There is no beep.

# The Display

**To adjust the contrast**

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

**The Parts of the Display**




**Annunciators**

| | |
|---|---|
| ⮌ | Shift in effect for next keystroke. To cancel, press ■ again. |
| α | Alpha in effect for next keystroke. To cancel, press [A...Z] again. |
| ((•)) | Low battery power. See chapter 9. |
| ⧗ | Busy. |
| ⋙ | Data is being transferred via infrared or cable. |
| ▲ ▼ | There is more history in the Home display. Scroll up or down to see it. |
| RAD | Radians angle mode is set for Home. |
| GRD | Grads angle mode is set for Home. |
| DEG | Degrees angle mode is set for Home. |

**To clear the display**

- Press [ON] to clear the edit line.
- Press ■ [CLEAR] to clear the edit line and the display history.

## Display Modes

You can set the Home modes in ■ [MODES]. You make your selections using an *input form*. To fill out an input form, see "Using Input Forms," after this table. *The Decimal Mark setting affects all aplets, as well as Home.*

When you are done setting MODES, press [HOME] to return to the Home screen.

**[MODES]**

| Setting | Options |
|---|---|
| **Angle Measure** | Angle values are:<br>**Degrees.** 360 degrees in a circle.<br>**Radians.** $2\pi$ radians in a circle.<br>**Grads.** 400 grads in a circle. |
| **Number Format** | **Standard.** Full-precision display.<br>**Fixed.** Displays results rounded to a number of decimal places. Example : 123.456789 becomes 123.4568 in Fixed 4 format.<br>**Scientific.** Displays result 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.<br>**Engineering.** Displays result with an exponent that is a multiple of 3, and the specified number of significant digits *beyond* the first one. Example: 123.456E7 becomes 1.23E9 in Engineering 2 format.<br>**Fraction.** Displays results as fractions based on the specified number of decimal places for precision. Examples: 123.456789 becomes 123 in Fraction 2 format, and .333 becomes 1/3 and 29/1000 becomes 2/69. |
| **Decimal Mark** | **Dot** or **Comma.** Displays a number as 12456.98 (Dot mode) or as 12456,98 (Comma mode). Dot mode uses commas to separate elements in lists and matrices, and to separate function arguments. Comma mode uses periods as separators in these contexts. |
| **Title** | Customizes the title in the Home screen. |

**To display fractions**

Set Fraction mode to display *future* results as fractions.

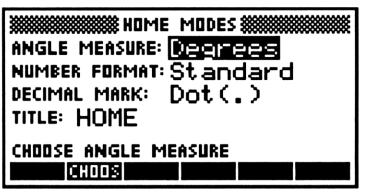
1. Press ■ [MODES], then press ▼ to select NUMBER FORMAT.
2. Press {{CHOOS}}, highlight `Fraction`, and press {{OK}}.
3. Press ▶ and enter a number for the precision of the fraction. The precision number determines how many digits appear in the denominator. Press ENTER.
4. Press HOME to display Home.

**To convert a result to a fraction**

1. Set Fraction mode (as in the previous procedure).
2. In Home, press ▲ to highlight the number in the history display that you want to convert.
3. Press {{COPY}} ENTER.

## Using Input Forms

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




**Example: Setting Modes**

Change the Angle Measure.

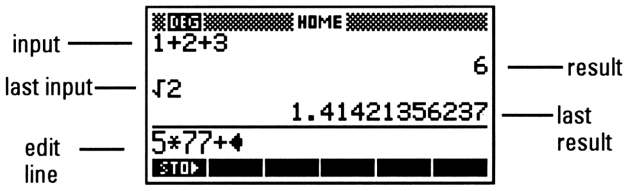
1. Press ■ [MODES] to open the MODES input form.
2. The cursor (highlight) should be on the first line, ANGLE MEASURE. Press {{CHOOS}} to display a list of choices. Highlight `Degrees, Radians, or Grads` and press {{OK}}.
3. When done, press HOME to return to Home.

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

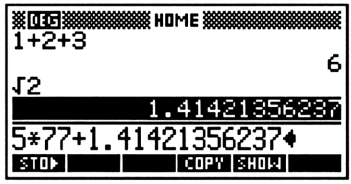
**To reset values** To reset the original, default value in an input form, press [DEL]. To reset *all values* in the form, press ■ [CLEAR].

## Home History

The Home display (press [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; press [▲] to view them. Note that these examples are in Standard display mode.




When you highlight a previous input or result (pressing [▲]) the {{COPY}} and {{SHOW}} menu labels appear. Pressing {{COPY}} copies the highlighted value to the edit line.




**To copy a previous line** Highlight the line (press [▲]) and press {{COPY}}. The number (or expression) is copied into the edit line.

**To repeat a previous line** To repeat the very last line, just press [ENTER]. Otherwise, highlight the line (press [▲]) first, and then press [ENTER]. The highlighted expression or number is re-entered.

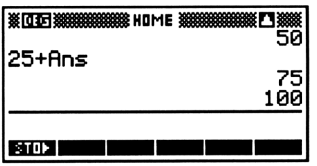
**To re-use a previous result**

Press ■ [ANSWER] (*last answer*) to put the last result from Home into an expression. *Ans* is a variable that is updated each time you press [ENTER].

**Example**

See how [ANSWER] retrieves and reuses the last result (50), and [ENTER] updates *Ans* (from 50 to 75 to 100).

50 [ENTER]
25[+] ■ [ANSWER]
[ENTER] [ENTER]




You can use the last result as the first expression in the edit line *without* pressing ■ [ANSWER]. Pressing [+], [-], [*], or [/], (or other operators that require a preceding argument) automatically enters *Ans* before the operator.

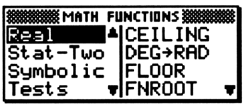
You can reuse any other expression or value in the Home display by highlighting the expression (using the arrow keys), then pressing {{COPY}}.

**To display the full number**

If a number or expression is too long to appear on one line, then highlight it (press [▲]) and press {{SHOW}}. If it is still too long, press [▶] to see more. When done, press {{OK}}.

## Menu Lists

A *menu* offers you a choice of items. The *menu labels* across the bottom of some displays are one kind of menu. A *menu list*, which appears in one or two columns, is another kind.


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

**To search a menu list**

- Press ▼ or ▲ to scroll through the list. If you press ■ ▼ or ■ ▲, you'll go all the way to the end or the beginning of the list. Highlight the item you want to select, then press {{OK}} (or ENTER).
- If there are two columns, the left column shows general categories and the right column shows specific contents. Highlight the category on the left, then highlight the item on the right. The list on the right changes when a different category is highlighted. Press {{OK}} or ENTER.
- To speed-search a list, type the first letter of the word. For example, to find the Matrix category in MATH, press **M** (the 9 key).
- To go up a page, you can press ■ ◄. To go down a page, press ■ ►.

**To cancel a menu list**

Press **CANCEL** or {{CANCL}}. This cancels the current operation.

# Aplets and Their Views

## Aplets

The HP 38G provides built-in applications to solve specific kinds of math problems. These little applications, or *aplets*, are accessed from the Library (LIB).

The Library lists (and manages) all the aplets in the calculator, whether they came with the calculator or were added later.

There are six types of math aplets built into the HP 38G :

**Function**

- Real-valued, rectangular function $y$ in terms of $x$. Example: $y = 2x+3$.

**Parametric**

- Parametric functions $x$ and $y$ in terms of $t$. Example: $x = \cos(t)$ and $y = \sin(t)$.

**Polar**

- Polar function $r$ in terms of an angle $\theta$. Example: $r = 2\cos(4\theta)$.

**Sequence**

- Sequence function $U$ in terms of $n$, or in terms of previous terms in the 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**

- Finding the roots of an equation. Example: $x + 1 = x^2 - x - 2$.

**Statistics**

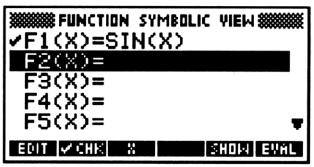
- Analysis of one-variable ($x$) or two-variable ($x$ and $y$) statistical data.

## Views

An aplet is represented in different ways. These *views* compose an aplet problem and its solution. Here are illustrations of three major and six supporting aplet views.

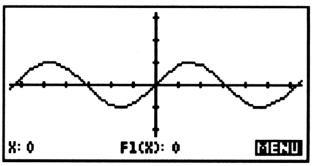
SYMB

**Symbolic view.** The defining equation(s) (in most aplets). The equation contains a *symbolic expression*.



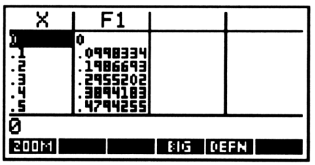

PLOT

**Plot view.** The graph of the function(s).



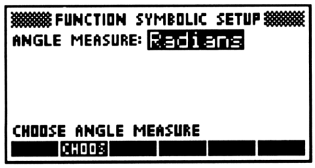

NUM

**Numeric view.** Sampled values of the function(s).



**■ [SETUP-SYMB]**

**Symbolic Setup** (■ SYMB). Sets parameters for the symbolic expression.

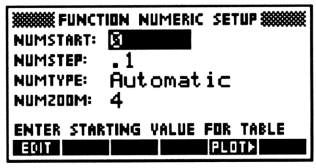



**■ [SETUP-PLOT]**

**Plot Setup** (■ PLOT). Sets parameters to plot a graph.

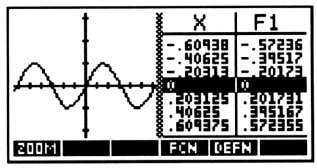

**■ [SETUP-NUM]**

**Numeric Setup** (■ NUM). Sets parameters for building a table of numeric values.



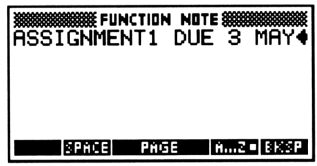

**■ [VIEWS] Plot-Table**

**Split Screen view**. Two views side by side.



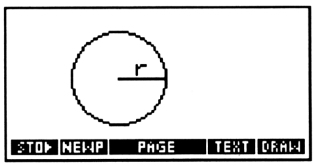

**■ [NOTE]**

**Note view**. Text to supplement an aplet.




**■ [SKETCH]**

**Sketch view**. Pictures to supplement an aplet.




**Changing Views**

Each view is a separate "environment." To change the view, press another view key. 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.

**Canceling Operations**

To cancel an operation *within* a view, press ON (the **CANCEL** key). Pressing **CANCEL** will cancel pending operations, but will not change the view.

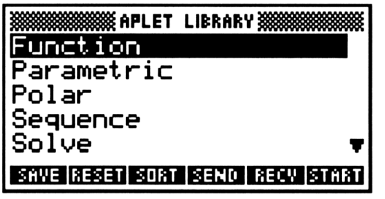
## Exploring an Aplet View by View

**Example**

Use the Function aplet to explore the real function $y = \sin(1/x)$ using the Symbolic, Plot, and Numeric views. *All the information you enter is automatically saved.*

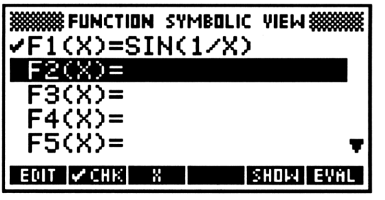
1. **Open the Function aplet.** Press LIB. If necessary, press ▼ to highlight `Function`.

   Then press {{START}} to display the Symbolic view.

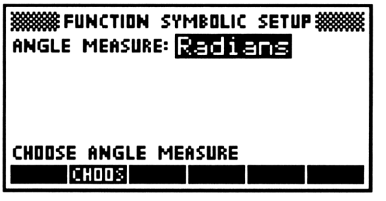



2. Enter the expression.
   (If necessary, highlight a new line or press DEL to clear the highlighted expression.)

   Press SIN 1 / {{X}} ENTER .

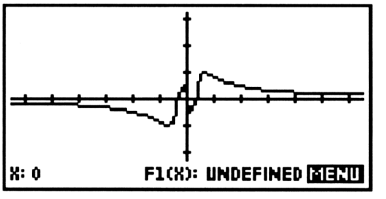



3. There are three Setup views. They are the shifted keystrokes for SYMB, PLOT, and NUM. Check that Radians are set for Symbolic Setup: Press ■ **[SETUP-SYMB]** and choose `Radians`, if necessary.

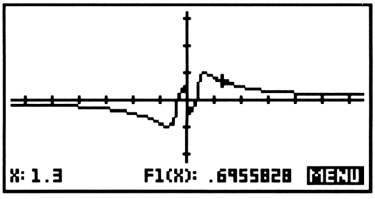



4. **Plot the graph.** Press PLOT. The coordinates show that when $x$=0, $f(x)$ is undefined.

   (If your plot does not look like this, try resetting the default plot settings: Press ■ **[SETUP-PLOT]** ■ **[CLEAR]**.)

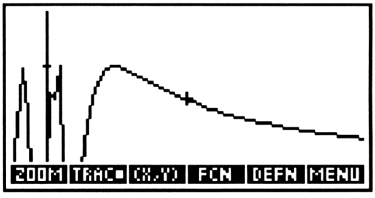


5. **Trace the plot.** Move the crosshairs along the plot by pressing ◀ and ▶.



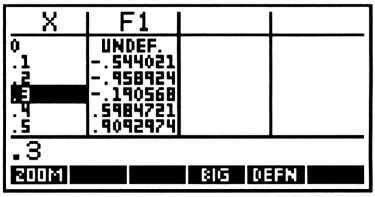

6. **Zoom in and zoom out.** Press {{MENU}} {{ZOOM}}, highlight `In 4×4, and` press {{OK}}.

   To restore the original scale, select {{ZOOM}} `Un-zoom`.



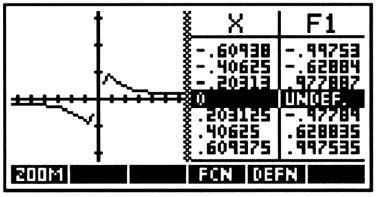

7. **Display the numbers.** To display a table of data, press NUM. You see the independent (X) and dependent (F1) variables listed with sampled values.

   (If your table does not look like this, try resetting the default numeric settings : Press ■ [SETUP-NUM] ■ [CLEAR].)




8. **Split the screen.** Press ■ [VIEWS], then select `Plot-Table` {{OK}} to display these two views simultaneously.

   Press PLOT to view the full-screen plot again.



**Automatic Saving**

With this example you have defined a new aplet—an aplet containing data for the solution of $y = \sin(1/x)$. *The data are automatically saved in the Function aplet.* If you want to create another aplet based on Function, then you can give this one a new name in the Library ({{SAVE}}).

To keep as much memory available for storage as possible, delete aplets you no longer need.

**Annotating with Notes**

The Note view (■ [NOTE]) attaches a note to the current aplet. See "Notes and Sketches" later in this chapter.

**Annotating with Sketches**

The Sketch view (■ [SKETCH]) attaches a picture to the current aplet. See "Notes and Sketches" later in this chapter.

**Calculating in Aplets**

You can do calculations in aplets wherever you can enter numbers or expressions. Use the math keys on the keyboard or use operations from the [MATH] menu list. Chapter 2 discusses math calculations.

# Catalogs and Editors

The HP 38G has several catalogs and editors. They access features and stored values (numbers or text or other items) that are not part of aplets. A *catalog* lists items, which you can delete or transmit. An *editor* lets you create or modify items and numbers.

**Catalogs/Editors**

| Catalog/Editor | Contents |
|---|---|
| Library ([LIB]) | Aplets. |
| List (■ [LIST]) | Lists. In Home, lists are enclosed in { }. |
| Matrix (■ [MATRIX]) | One- and two-dimensional arrays. In Home, arrays are enclosed in [ ]. |
| Notepad (■ [NOTEPAD]) | Notes (short text entries). |
| Program (■ [PROGRAM]) | Programs created by a user. |

# Storing and Recalling Variables

*Variables* are storage locations for numbers or values. The HP 38G has different categories of variables for different kinds of data. The *names* for the variables are predefined. For real numbers, there are 27 variable names available, A through Z and θ. (Other categories and their names are in chapter 2.)

A variable holds just one value, so if you store a new number in it, any previous number is lost.

**To store a number**

You can store a number from Home's edit line into a named variable with the {{STO▶}} (*store*) menu key. ({{STO▶}} appears on a menu-key label whenever it is possible to store a value.) For example,

| | |
|---|---|
| **75**{{STO▶}} [A...Z]**A** | 75▶A |
| [ENTER] | 75 |

When you press [ENTER], the number 75 is stored into the variable named A.

To store the last answer, you don't need to re-type the number:

| | |
|---|---|
| {{STO▶}} [A...Z]**B** | Ans▶B |
| [ENTER] | 75 |

This stores 75 (the last result) in B.

**To recall a number**

In Home, to recall a value from a stored variable back to the edit line, just type the name of the variable and press [ENTER].

| | |
|---|---|
| [A...Z]**A** [ENTER] | 75 |

**"Deleting" Variables**

A variable always has a value in it, even if that value is zero. When you store another value into a variable, it overwrites the previous value. So you cannot *delete* a variable's value, but you can *overwrite* it.

The predefined variable names (such as A through Z) always exist; you cannot change or delete them.

**Home and Aplet Variables**

Most variables are *Home variables*, which means they are shared throughout the different contexts of the calculator. Some variables are *aplet variables*, which means they apply only to the current aplet. Aplet variables are data sets, expressions, and settings made within an aplet.

# Notes and Sketches

The HP 38G has compact text and picture editors for entering *notes* and *sketches*.

- **The Notepad** is an independent collection of notes.
- *Each aplet* includes a **Note view** and a **Sketch view** for that aplet only.

## Note View and Sketch View

You can attach text *to an aplet* in its Note view (■ [NOTE]), or attach pictures to it in its Sketch view (■ [SKETCH]).

**To write a note in Note view**

1. In an aplet, press ■ [NOTE] for the Note view.
2. Use the note editing keys shown below.
3. Set Alpha lock ({{A...Z}}) for quick entry of letters. For *lowercase* Alpha lock, press ■ {{A...Z}}.
   - To type a single letter of the opposite case, press ■ *letter*.
4. *Your work is automatically saved.* When done, turn off Alpha lock (by pressing {{A...Z■}}) if you want to go to Home. (Otherwise, the [HOME] key will still type A.)

**Note Editing Keys**

| Key | Meaning |
|---|---|
| {{SPACE}} | Space key for text entry. |
| {{▲PAGE}} | Displays previous page of the note. |
| {{PAGE▼}} | Displays next page of the note. |
| {{A...Z}} | Alpha-lock for letter entry. |
| ■ {{A...Z}} | Lower-case Alpha-lock. |
| {{BKSP}} | Backspaces cursor and deletes character. |
| DEL | Deletes current character. |
| ENTER | Starts a new line. |
| ■ [CLEAR] | Erases the entire note. |
| VAR | Menu for entering variable names, and contents of variables. |
| MATH | Menu for entering math operations, program commands, and constant names. |
| ■ [CHARS] | Displays special characters. To type one, highlight it and press {{ECHO}}. Pressing {{OK}} copies the character *and* closes the CHARS screen. |

**To import a note**

You can import a note from the Notepad into an aplet's Note view, and vice-versa.

1. Open the destination note in the Notepad or in the Note view of an aplet.
2. Press VAR.
   - If the source note is in the Notepad, press {{HOME}}, highlight `Notepad` in the left-hand list, then highlight the name of the source note in the right-hand list.
   - If the source note is part of the current aplet, press {{APLET}}, highlight `Note` in the left-hand list, then press ▶ and highlight `NoteText` in the right-hand list.
3. Press {{VALUE}} {{OK}} to recall the *contents* of the source note into the destination note.

**Sketch Keys**

| Key | Meaning |
|---|---|
| {{STO▶}} | Stores the specified portion of the current sketch to a graphics variable (G1 through G0). |
| {{NEWP}} | Adds a new, blank page to the current sketch set. |
| {{▲PAGE}} | Displays previous sketch in the sketch set. Animates if held down. |
| {{PAGE▼}} | Displays next sketch in the sketch set. Animates if held down. |
| {{TEXT}} | Opens the edit line to type a text label. |
| {{DRAW}} | Displays the menu-key labels for drawing (below). |
| DEL | Deletes the current sketch. |
| ■ [CLEAR] | Erases the entire sketch set. |
| - | Turns off the menu-key labels. Press any menu key to restore them. |

**To draw a sketch**

1. In an aplet, press ■ [SKETCH] for the Sketch view.
2. Press {{DRAW}}.
3. Use the arrow keys to move the crosshairs (graphics cursor). To draw lines, boxes, or circles, use the menu keys (described next).
4. When done drawing, press {{OK}}. *Your work is automatically saved.* Press any other view key or HOME to exit the Sketch view.

**To draw a line**

1. In Sketch view, press {{DRAW}} and move the cursor to where you want to start the line
2. Press {{LINE}}. This turns on line-drawing.
3. Move the cursor in any direction to the end point for the line.
4. Press {{OK}} to finish the line.

**To draw a box**

1. In Sketch view, press {{DRAW}} and move the cursor to where you want any corner of the box to be.
2. Press {{BOX}}. This turns on box-drawing.
3. Move the cursor to mark the opposite corner for the box. You can adjust the size of the box by moving the cursor.
4. Press {{OK}} to finish the box.

**To draw a circle**

1. In Sketch view, press {{DRAW}} and move the cursor to where you want the center of the circle to be.
2. Press {{CIRCL}}. This turns on circle-drawing.
3. Move the cursor the distance of the radius.
4. Press {{OK}} to draw the circle.

**DRAW Keys**

| Key | Meaning |
|---|---|
| {{DOT+}}, {{DOT−}} | *Dot on, dot off.* Turns pixels on/off as crosshairs move. |
| {{LINE}} | Draws a line from the cursor's starting position to the point at which you press {{OK}}. You can draw a line at any angle by moving the cursor. |
| {{BOX}} | Draws a box from the cursor's starting position to the point at which you press {{OK}}. |
| {{CIRCL}} | Draws a circle. The cursor's starting position is the center of the circle. The cursor's ending position (when you press {{OK}}) defines the radius. |

**To label parts of a sketch**

1. Press {{TEXT}} and type the text in the edit line. To lock the Alpha shift on, press {{A...Z}} (for uppercase) or ■ {{A...Z}} (for lowercase).
2. To make the label a smaller character size, turn off {{BIG■}}. (Pressing {{BIG}} turns on {{BIG■}} and vice-versa.) The smaller character size cannot display lowercase letters.
3. Press {{OK}}. Use the arrow keys to position the label where you want it.
4. Press {{OK}} again to affix the label.
5. Press {{DRAW}} to continue drawing, or press HOME to exit Sketch view.

**To create a set of sketches**

You can create a sequence of up to ten sketches. This allows for simple animation.

- After making a sketch, press {{NEWP}} to add a new, blank page that will follow the current page. You can now make a new sketch. The new image becomes part of the current set of sketches.
- To view the next sketch in an existing set, press {{PAGE▼}}. Hold {{PAGE▼}} down for animation.
- To remove the current page in the current sketch series, press DEL.

**To store into a graphics variable**

You can define a portion of a sketch inside a box, and then store that graphic into a graphics variable.

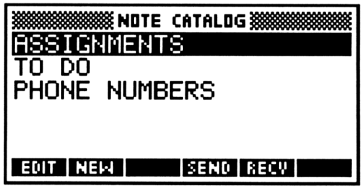
1. In the Sketch view, display the sketch you want to copy (store into a variable).
2. Press {{STO▶}}. Highlight the variable name you want to use and press {{OK}}.
3. Draw a box around the whole screen or around the portion you want to copy: move the cursor to one corner, press {{OK}}, then move the cursor to another corner and press {{OK}}.

**To recall a graphics variable**

1. Open the Sketch view in the destination aplet.
2. Press [VAR] {{HOME}}. Highlight `Graphic`, then press [▶] and highlight the name of the variable (G1, etc.).
3. Press {{VALUE}} {{OK}} to recall the *contents* of the graphics variable.
4. Move the box to where you would like to copy the graphic, then press {{OK}}.

## The Notepad

You can store as many notes as you want in the Notepad (■ [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 Note view* (■ [NOTE]).



**To write a note in the Notepad**

1. In the Notepad, press {{EDIT}} to modify the highlighted note or press {{NEW}} to start a new note. For a new note, type in a name and press {{OK}}.
2. This opens the note for you to write and edit. Use the Note editing keys as in Note view (see page 1-19).
3. When you are done, you can leave the Notepad by pressing HOME or an aplet view key. *Your work is automatically saved.*

**Notepad Catalog Keys**

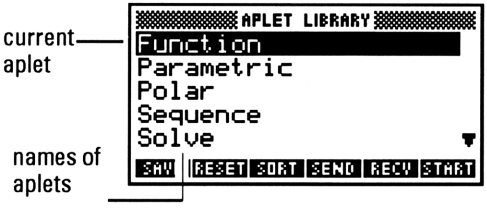
| Key | Meaning |
|---|---|
| {{EDIT}} | Opens the selected note for editing. |
| {{NEW}} | Opens a new note, and asks for a name. |
| {{SEND}} | Transmits the selected note to another HP 38G or a disk drive. See also page 1-27. |
| {{RECV}} (*receive*) | Receives a note being transmitted from another HP 38G or a disk drive. See also page 1-27. |
| DEL | Deletes the selected note. |
| ■ [CLEAR] | Deletes all notes in the catalog. |

# Managing Aplets

[LIB]

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 Library is where you go to manage your aplets. Press [LIB]. Highlight (using the arrow keys) the name of the aplet you want to act on.




The current aplet is highlighted.

**Library Keys**

| Key | Meaning |
|---|---|
| {{SAVE}} | Saves the highlighted aplet with a name. |
| {{RESET}} | Resets the default values and settings in the highlighted aplet. |
| {{SORT}} | Rearranges the aplet list. |
| {{SEND}} | Transmits the highlighted aplet to another HP 38G or a storage device. |
| {{RECV}} (*receive*) | Receives the aplet being sent from another HP 38G or storage device. |
| {{START}} (or [ENTER]) | Opens the highlighted aplet. |

**To open an aplet**

- Press [LIB] to open the Library. Highlight the aplet and press {{START}} or [ENTER]. The aplet's main view appears.
- Instead of pressing {{START}}, you can press a view key (like [PLOT], [SYMB], or [NUM]) to immediately display that view of the aplet.

**To name an aplet**

1. Press [LIB] to open the Library. Highlight the aplet to name.
2. Press {{SAVE}} and enter a name. Press {{OK}} to confirm it, {{CANCL}} to cancel it.

**To create a new aplet**

You can create a new aplet based on an existing aplet.

1. Open the aplet you want to start from.
2. Enter or modify its information (equations, data, settings). This defines a new version of the aplet. All information is saved until you clear it or edit it.
3. To name the aplet for future access, use {{SAVE}} in the Library.

**To delete an aplet**

Open the Library, highlight the custom (not built-in) aplet to delete, and press [DEL]. To delete *all* custom aplets, press ■ [CLEAR].

*You cannot delete the built-in aplets.* You can clear their data and reset default settings using {{RESET}}.

**To clear an aplet**

*Resetting* an aplet clears all data and resets all default settings.

- To reset an aplet, open the Library, select the aplet and press {{RESET}}.

**To sort the aplet list**

In the Library, press {{SORT}}. Select the sorting scheme and press [ENTER].

- **Chronologically** produces a chronological order by most recent use of the aplets. (The last-used aplet appears first, and so on.)
- **Alphabetically** produces an alphabetical order by aplet name.

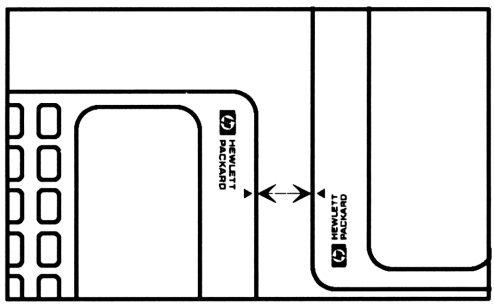
# Sending and Receiving Aplets

A convenient way to distribute or share problems in class and to turn in homework is to transmit (copy) aplets directly from one HP 38G to another. This takes place via the *infrared* port.

You can also send (copy) and receive aplets to/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 or Mac (such as a connectivity kit).

**To transmit an aplet**

1. Connect the storage device to the calculator by cable
   *or*
   align the two calculators' infrared ports by matching up the triangle marks on the rims of the calculators. Place the calculators no more than 2 inches (5 cm) apart.




2. **Sending calculator** : Open the Library, highlight the aplet to send, and press {{SEND}}.
   - You have two options : another HP 38G or a disk drive (or a computer). Highlight your selection and press {{OK}}.
   - If transmitting to a disk drive (aplet disk drive or computer), you have the options of sending to the current (default) directory or to another directory.

3. **Receiving calculator :** Open the Library and press {{RECV}}.

   - You have two options : another HP 38G or a disk drive (or computer). Highlight your selection and press {{OK}}.

If receiving from a remote storage device (aplet disk drive or computer), you will see a list of aplets in its current directory. You can choose a different directory to copy from. Check as many items as you would like to receive.

# 2

# Mathematical Calculations

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

The MATH menu also contains commands to use for programming.

## How to Do Calculations

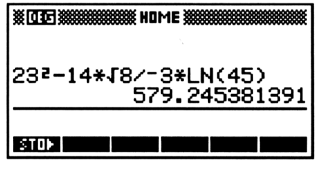
**Where to Start** The home base for the calculator is Home (press [HOME]). You can do all calculations here, and you can access all [MATH] operations.

### Entering Expressions

- Enter an expression into the HP 38G 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 use Alpha keys to spell out a function's 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 $23^2-(14\sqrt{8})\div(-3)\ln 45$ with these keystrokes.

23 ■ [$x^2$] [-] [(] 14 [*] [$\sqrt{x}$]
8 [)] [/] [-x] 3 [*] ■ [LN] 45
[)] [ENTER]



**Long Results**

If the result is too long to fit in the display line, press ▲ to highlight it and then press {{SHOW}}.

**Negative Numbers**

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

If a negative number will be raised to a power, enclose it in parentheses. For example, $(-5)^2 = 25$, whereas $-5^2 = -25$.

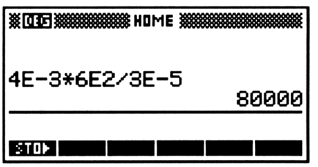
**Scientific Notation (Powers of 10)**

A number like $5\times10^4$ or $3.21\times10^{-7}$ 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 [*] 10 [$x^y$].)

**Example**

Calculate $\dfrac{(4\times10^{-3})(6\times10^{2})}{3\times10^{-5}}$ as shown :

4 ■ [EEX] [-x] 3 [*] 6
■ [EEX] 2 [/] 3 ■ [EEX]
[-x] 5 [ENTER]




**Explicit and Implicit Multiplication**

You should include the times sign where you expect multiplication in an expression. It is clearest to enter *AB* as A*B, and *A(B+C)* as A*(B+C).

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

**Parentheses**

Parentheses are necessary to enclose arguments for functions, such as SIN(45). You can omit the final parenthesis at the end of an edit line.

Parentheses are also important in specifying the order of operation. *Without* parentheses, the HP 38G calculates according to the order of *algebraic precedence* (the next topic). Following are some examples using parentheses.

### Examples

| Entering... | Calculates... |
|---|---|
| SIN 45 + ■ [π] | sin (45 + π) |
| SIN 45 ) + ■ [π] | sin (45) + π |
| √x 85 * 9 | $\sqrt{85} \times 9$ |
| √x ( 85 * 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, =.

**Fractions**

The HP 38G can display fractions of the form *a*/*b*. To set Fractions mode, select Fractions as the Number Format in Home Modes (■ [MODES]). Specify the number of decimal places to use for the denominator. For instance, in Fraction 2 format, 29/1000 becomes 2/69 .

To enter a fraction use the / key.

**Largest and Smallest Numbers**

The smallest number the HP 38G can represent is $1 \times 10^{-499}$ (1E-499). A smaller result is displayed as zero. The largest number is $9.99999999999 \times 10^{499}$. A larger result is still displayed as this number.

## Complex Numbers

**Complex Results**

The HP 38G 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* + `i`*y*.

To type `i`, press ■ [A...Z] I, or copy `i` from the Constant category in the MATH menu.

## Clearing Numbers

- [DEL] clears the character under the cursor (◆). [DEL] backspaces when the cursor is after the last character.
- **CANCEL** ([ON]) clears the edit line.
- ■ **[CLEAR]** clears all input and output in the display, including the display history.

## Using Previous Results

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

**Last Answer ([ANSWER])**

You can reuse the last answer at any point in the edit line by pressing ■ **[ANSWER]**. This recalls the variable *Ans* (*last answer*), the result from your last [ENTER].

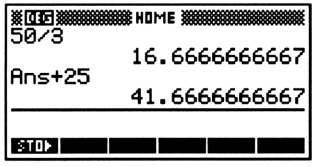
The variable *Ans* is different from the numbers in Home's display history. A value in *Ans* is stored internally with the full precision of the calculated result, whereas the displayed numbers match the display mode. When you retrieve a number from *Ans*, you obtain the result to its full precision. When you retrieve a number from Home's display history, you obtain exactly what was displayed.

Note that pressing ENTER enters (or re-enters) the *last input*, whereas pressing ■ [ANSWER] copies the *last result* into the edit line.

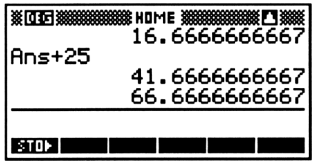
**Continuing a Calculation**

You can continue calculating with your last result, *Ans*, simply by pressing an operator key.

50 / 3 ENTER
+ 25 ENTER




Pressing ENTER again updates the value of *Ans* and repeats the operation.




**Accessing the Display History**

Pressing ▲ turns on the highlight bar in the display history.

| Key | Meaning |
|---|---|
| ▲, ▼ | Scroll through the display history and highlight display lines. |
| {{COPY}} | Copies the highlighted expression to the position of the cursor in the edit line. |
| {{SHOW}} | Displays the current expression in standard mathematical form. |
| DEL | Deletes the highlighted expression from the display history, unless there is a cursor in the edit line. |
| ■ [CLEAR] | Clears all lines of display history and the edit line. |

**Clearing the Display History**

It's a good habit to clear the display history (■ [CLEAR]) whenever you are done 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.

**Clearing the Edit Line**

- [DEL] deletes single characters in the edit line.
- [ON] (CANCEL) clears the entire edit line.

# Storing in Variables

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

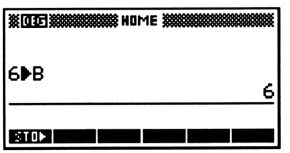
**Numeric Precision**

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.

**To store a value**

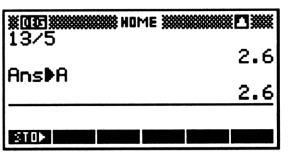
Press {{STO▶}} [A...Z] *letter* [ENTER], where *letter* represents the one-letter variable name for real numbers.

6 {{STO▶}} [A...Z] B
[ENTER]




You can store the last answer the same way:

13 [/] 5 [ENTER]
{{STO▶}} [A...Z] A [ENTER]




**To store any previous value**

If the value you want to store is somewhere else in the Home history, first copy it to the edit line: highlight the line (using arrow keys) and press {{COPY}}. Then store it.

**To recall a value**

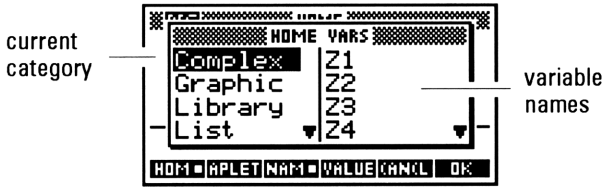
Type the name of the variable and press [ENTER].

[A...Z] A [ENTER] **2.6**

# The VAR Menu

Another way to retrieve a variable is to use the VAR (*variables*) menu. The VAR menu contains the *Home variables*, as well as the *aplet variables* for the current aplet.

The VAR menu is organized by *category*. For each category of variables on the left, there is a list of variables on the right. The highlighted category is the *current category*.




The {{HOME}} and {{APLET}} menu keys switch to Home and Aplet variables. The ■ symbol indicates what is "on": {{HOM■}} means that the Home variables are displayed.

**Home Variables**

The Home variables are the ones you most commonly use while doing calculations in Home. Any value (or other data) you store must be stored in a variable of the correct type.

| Category | Available Names |
|---|---|
| Complex | Z1 through Z9 and Z0. |
| Graphic | G1 through G9 and G0. |
| Library | aplets |
| List | L1 through L9 and L0. |
| Matrix | M1 through M9 and M0. |
| Modes | The MODES screen (■ [MODES]) stores values in these variables. |
| Notepad | User-provided. |
| Program | User-provided. |
| Real | A through Z and θ. |

Home variables retain their values regardless of context: Home, the aplets, and the editors recognize the Home variables and retain whatever was last stored in them. This sharing allows you to work on the same problem in different places (such as Home and the Function aplet) without having to update a variable whenever it is recalculated.

If you have not stored anything in a real variable, then it contains the value zero. (It is never "empty.")

**To access a Home variable**

1. Press [VAR] to display the VAR menu. Set {{HOM■}}, if necessary by pressing {{HOME}}.
2. Use [▼] and [▲] to scroll through the alphabetical list of categories. To skip directly to a starting letter, press a letter key. To switch between the category list (left) and the variable list (right), use [▶] and [◀].
3. Highlight the name of the variable you want.
   - To copy the **name** of the variable into the edit line, press {{OK}}. (NAME is set: the menu label shows {{NAM■}}).

To copy the **value** of the variable into the edit line, set VALUE (press {{VALUE}} to make it {{VALU■}}) and press {{OK}}.

**Aplet Variables**

The variable types in the table below are aplet variables that you use to define aplet functions and to store some kinds of aplet data. They are usually found in the Symbolic view or the Numeric view of an aplet.

| Aplet Category | Available Names |
|---|---|
| Function | F1 through F9 and F0 (Symbolic view) |
| Parametric | X1, Y1 through X9, Y9 and X0, Y0 (Symbolic view) |
| Polar | R1 through R9 and R0 (Symbolic view) |
| Sequence | U1 through U9 and U0 (Symbolic view) |
| Solve | E1 through E9 and E0 (Symbolic view) |
| Statistical data | C1 through C9 and C0 (Numeric view) |

As you load new aplets in the HP 38G, their names and variables will be added to the VAR menu.

In addition, there are other aplet variables that are record settings, such as those in the Setup views. These types of variables (like NumStart and Xtick) are listed in chapter 8, Programming, since you do not need to know their names except when programming.

**To access an aplet variable**

The {{APLET}} menu key in the VAR menu switches the menu list to aplet variables. The ■ symbol indicates what is "on": {{APLE■}} means that aplet variables are displayed.

1. Open the aplet whose variable you want to recall.
2. Press [VAR] to display the VAR menu. Set {{APLE■}}, if necessary by pressing {{APLET}}.


3. Highlight the view on the left side. If you're not sure which view it's in, just scroll through the view names and check the names of the variables on the right.
4. Press {{OK}} or [▶] to switch to the list of variable names on the right side.
5. Highlight the name of the variable you want. To copy its name, turn on {{NAM■}}. To retrieve its value, turn on {{VALU■}}. Press {{OK}}.

You can do this in Home *if* the aplet you want is current; that is, it was the last one open.

# Symbolic Calculations

**Formal Names**

A *formal name* acts as a placeholder—it does not represent a value, just a symbol. In Home or in a program, the expression `(s1*s2)^2` always returns the expression `(s1*s2)^2`. The real variables in `(A*B)^2`, on the other hand, are evaluated to a number, the value of which depends on what is currently stored in *A* and *B*.

**Note**

**Remember that there is always a value in a real variable, even if it is zero.**

You can mix formal names and real variables. Evaluating `(A*s2)^2` will substitute a number for *A* but not for *s2*.

If you want to evaluate an expression like `(s1*s2)^2` numerically, you can do so using the | (*where*) command, listed in the MATH menu under the Symbolic category. For instance, if you wanted *s1* = 3 and *s2* = 4, you would enter `(s1*s2)^2 | (s1=3,s2=4)`. (The = symbol is in the CHARS menu: press ■ [CHARS] {{OK}}).

**Indefinite Integrals**

To find the indefinite integral (with a symbolic rather than numeric result), use formal variables (that is, s0 through s5) for a limit of integration. For instance, to compute $\int(6x-5)dx$, enter the integration as `∫(0,s1,6*X^2-5,X)`. `0` and `s1` are the lower and upper limits, and `X` is the variable of integration.

1. Enter the the integration expression in the Home edit line. (The ∫ symbol in the the CHARS menu.)
2. Press [ENTER], which produces an intermediate result.
3. Press ▲ {{COPY}} [ENTER] to complete the evaluation.

The result of ∫(0,s1,6*X2−5,X) should be −(5*s1)+6*(s1^3/3), that is, 2x3−5x.Translators: in Comma mode: change syntax to use periods.

**Definite Integrals**

To find the definite integral (with a numeric result), use numeric values (numbers or real variables containing numbers) for both the upper and lower limits. For instance, if you enter ∫(−2,3,6*X2−5,X)and press [ENTER] , the result is 45.

**Derivatives**

To find the symbolic derivative of an expression, use a formal variable (`s1`, etc.) to define the derivative. For example, to find $D_x(6x^2-5x)$, enter `∂s1(6*s1^2-5*s1)`.The result is `6*(2*s1)-5`, which is equal to $12x-5$.

If you use real variables or numbers in the derivative, the calculator will find a numeric result.

**Composition of Functions** You can define a function of another function using the Function aplet ([LIB] `Function`). That is, $f(g(x))$ can be entered into the Symbolic view of Function as

`F1(X)` = *expression1*
`F2(X)` = *expression2*
`F3(X)` = `F1(F2(X))`

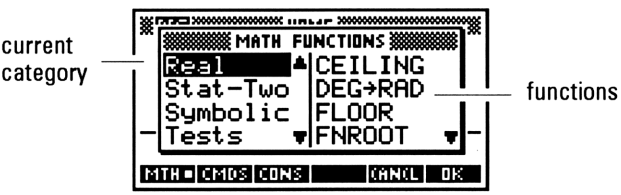
# Using Math Functions

**Selecting Functions** To enter a function, type it in *or* select its name from the MATH menu.

## The MATH Menu

The MATH menu provides access to *Math Functions*, *Programming Commands*, and *Programming Constants*.

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




- When you press [MATH], you see the menu list of Math Functions. The menu key {{`MTH■`}} indicates that the Math Functions list is "on."
- To display the menu list of Program Commands, press {{`CMDS`}}. To display the menu list of Program Constants, press {{`CONS`}}. To re-display the Math Functions, press {{`MTH`}}.

The programming commands and programming constants are discussed in chapter 8, Programming.

**To copy a function**

1. Press [MATH] to display the MATH menu. The categories appear in alphabetical order. Use [▼] and [▲] to scroll through the categories. To skip directly to a starting letter, press a letter key.
2. The list of functions (on the right) applies to the currently highlighted category (on the left). Use [▶] and [◀] to switch between the category list and the function list.
3. Highlight the name of the function you want and press {{OK}}. This copies the function name (and an initial parenthesis, if appropriate) to the edit line.

**Function Categories**

- Calculus
- Complex numbers
- Constant
- Hyperbolic trig
- Lists
- Loop
- Matrices
- Polynomial
- Probability
- Real numbers
- Statistics-Two Variable
- Symbolic
- Tests
- Trigonometry

## The Math Functions by Category

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

**Syntax**

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

**Keyboard Functions**

The most frequently used functions appear on the keyboard. The keyboard functions are the only math functions that do not appear in the MATH menu. Many of the keyboard functions also accept complex numbers as arguments.

| | |
|---|---|
| [+], [-], [*], [/] | Add, Subtract, Multiply, Divide. Also accept complex numbers.<br><br>*value1*+ *value2*, etc. |
| ■ [$e^x$] | Natural exponential. Also accepts complex numbers.<br><br>`e^`*value* |
| ■ [LN] | Natural logarithm. Also accepts complex numbers.<br><br>`LN(`*value*`)` |
| ■ [$10^x$] | Exponential (antilogarithm). Also accepts complex numbers.<br><br>`10^`*value* |
| ■ [LOG] | Common logarithm. Also accepts complex numbers.<br><br>`LOG(`*value*`)` |
| [SIN], [COS], [TAN] | Sine, cosine, tangent. Inputs and outputs depend on the current angle format (Degrees, Radians, or Grads).<br><br>`SIN(`*value*`)`<br>`COS(`*value*`)`<br>`TAN(`*value*`)` |
| ■ [ASIN] | Arc sine : $\sin^{-1}x$. Output ranges from $-90°$ to $90°$, $-\pi/2$ to $\pi/2$, or $-100$ to 100 grads. Inputs and outputs depend on the current angle format.Also accepts complex numbers.<br><br>`ASIN(`*value*`)` |
| ■ [ACOS] | Arc cosine: $\cos^{-1}x$. Output ranges from $0°$ to $180°$, 0 to $\pi$, or 0 to 200 grads. Inputs and outputs depend on the current angle format. Also accepts complex numbers.<br><br>`ACOS(`*value*`)` |

■ [ATAN] Arc tangent : $\tan^{-1}x$. Output ranges from $-90°$ to $90°$, $-\pi/2$ to $\pi/2$, or $-100$ to 100 grads. Inputs and outputs depend on the current angle format. Also accepts complex numbers.

ATAN(*value*)

■ [$x^2$] Square. Also accepts complex numbers.

*value*$^2$

[$\sqrt{x}$] Square root. Also accepts complex numbers.

$\sqrt{}$*value*

■ [π] Pi, a constant.

π

■ [$x^{-1}$] Multiplicative inverse (reciprocal). For a complex number, the reciprocal is

$$\left(\frac{x}{x^2+y^2}, \frac{-y}{x^2+y^2}\right)$$

*value*^−1

[-*x*] Negation. Also accepts complex numbers.

−*value*

[$x^y$] Power (*x* raised to *y*). Also accepts complex numbers.

*value*^*power*

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

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

■ $\sqrt[n]{x}$ Takes the *n*th root of *x*.

*root*NTHROOT*value*
Example: 3 ■ $\sqrt[n]{x}$ 8 returns 2.

**Calculus Functions**

You will find the symbols for the calculus functions derivative and integral in the CHARS menu (■ [CHARS]) as well as the MATH menu.

| | |
|---|---|
| ∂ | Differentiates *expression* with respect to the *variable* of differentiation. Use a formal variable (s1, etc.) for a non-numeric result.<br><br>∂*variable*(*expression*)<br><br>Example: ∂s1(s1²+3*s1) returns 2*s1+3 |
| ∫ | Integrates *expression* from *lower* to *upper* limits with respect to the *variable* of integration. To find the definite (numeric) 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.).<br><br>∫(*lower*,*upper*,*expression*,*variable*)<br><br>Example: ∫(0,s1,2*X+3,X) ENTER ▲ {{COPY}} ENTER finds the indefinite result 3*s1+2*(s1^2/2) |
| TAYLOR | Calculates the *n*th order Taylor's polynomial of *expression* at the point where the given *variable* =0.<br><br>TAYLOR(*expression*,*variable*,*n*) |

**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 in Modes.<br>`ARG(` $(r,\theta)$ `)` |
| **CONJ** | Complex conjugate. Conjugation is the negation (sign reversal) of the imaginary part of a complex number.<br>`CONJ(` $(x,y)$ `)` |
| **IM** | Imaginary part, $y$, of a complex number, $(x,y)$.<br>`IM` $((x,y))$ |
| **RE** | Real part $x$, of a complex number, $(x,y)$.<br>`RE` $((x,y))$ |

**Constants** The HP 38G has an internal numeric representation for these constants.

| | |
|---|---|
| **e** | Natural logarithm base. Internally represented as 2.71828182846.<br>`e` |
| **i** | Imaginary value for $\sqrt{-1}$ , the complex number (0,1).<br>`i` |
| **MAXREAL** | Maximum real number. Internally represented as $9.99999999999\times10^{499}$.<br>`MAXREAL` |
| **MINREAL** | Minimum real number. Internally represented as $1\times10^{-499}$<br>`MINREAL` |
| **π** | The ratio perimeter : diameter. Internally represented as 3.14159265359.<br>`π` |

**Hyperbolic Trigonometry**

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

| | |
|---|---|
| **ACOSH** | Inverse hyperbolic cosine : $\cosh^{-1}x$.<br>`ACOSH(`*value*`)` |
| **ALOG** | Antilogarithm (exponential). This is more accurate than `10^x` due to limitations of the power function.<br>`ALOG(`*value*`)` |
| **ASINH** | Inverse hyperbolic sine : $\sinh^{-1}x$.<br>`ASINH(`*value*`)` |
| **ATANH** | Inverse hyperbolic tangent : $\tanh^{-1}x$. If the input is $\pm 1$, an `Infinite Result` occurs.<br>`ATANH(`*value*`)` |
| **COSH** | Hyperbolic cosine : $(e^x+e^{-x})/2$.<br>`COSH(`*value*`)` |
| **SINH** | Hyperbolic sine.<br>`SINH(`*value*`)` |
| **TANH** | Hyperbolic tangent.<br>`TANH(`*value*`)` |
| **EXP** | Natural exponential. This is more accurate than `e^x` due to limitations of the power function.<br>`EXP(`*value*`)` |
| **EXPM1** | Exponent minus 1 : $e^x-1$. This is more accurate than EXP when $x$ is close to zero.<br>`EXPM1(`*value*`)` |
| **LNP1** | Natural log plus 1 : $\ln(x+1)$. This is more accurate than LN when $x$ is close to zero.<br>`LNP1(`*value*`)` |

**List Functions** These functions are for list data stored in list variables. See chapter 7, Using Lists.

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

| | |
|---|---|
| **ITERATE** | Repeatedly (the specified *#times*) evaluates an *expression* in terms of *variable*. The value for *variable* is updated each time, starting with *initialvalue*.<br>`ITERATE(`*expression*`,` *variable*`,` *initialvalue*`,` *#times*`)` |
| **RECURSE** | Provides a method of defining a sequence without using the Symbolic view of the Sequence aplet.<br>`RECURSE(`*sequencename*`,` *term-n*`,` *term1*`,` *term2*`)`<br>Example: `RECURSE(U,U(N-1)*N,1,2){{STO▶}}U1(N)`<br>This produces the factorial<br>`U1(1)=1`<br>`U1(2)=2`<br>`U1(N)=U1(N-1)*N` |
| **Σ** | Summation. Finds the sum of *expression* with respect to *variable* from *initialvalue* to *finalvalue*.<br>`Σ(`*variable=initialvalue*`,` *finalvalue*`,` *expression*`)`<br>Example: `Σ(C=1,5,C²)` returns 55. |

**Matrix Functions** These functions are for matrix data stored in matrix variables. See chapter 8, Using Matrices.

**Polynomial Functions**

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

**POLYCOEF**

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

`POLYCOEF([`*roots*`])`

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

**POLYEVAL**

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

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

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

**POLYFORM**

Polynomial form. Creates a polynomial in *variable1* from *expression*. Can express the coefficients as a polynomial in *variable2*. (The coefficients of the coefficients can be expressed as polynomials in *variable3*, etc.)

`POLYFORM(`*expression*`,`*variable1*`,...,`*variable-n*`)`

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]`.

**Probability Functions** Probability functions are often used in statistical analyses.

| | |
|---|---|
| **COMB** | Number of combinations (without regard to order) of *n* things taken *r* at a time, $n!/(r!(n-r))$.<br><br>`COMB` (*n*, *r*) |
| **!** | Factorial of a positive integer. For non-integers, $! = \Gamma(x+1)$.<br><br>*value* ! |
| **PERM** | Number of permutations (with regard to order) of *n* things taken *r* at a time, $n!/(n-r)!$.<br><br>`PERM` (*n*, *r*) |
| **RANDOM** | Random number (between zero and 1). Produced by a pseudo-random number sequence. Becomes the seed for the next random number.You can set the seed using the command RANDSEED.<br><br>`RANDOM` |
| **UTPC** | Upper-Tail Chi-Squared Probability given *degrees* of freedom, evaluated at *value*. Returns the probablility that a $\chi^2$ random variable is greater than *value*.<br><br>`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*.<br><br>`UTPF` (*numerator*, *denominator*, *value*) |
| **UTPN** | Upper-Tail Normal Probability given *mean* and *variance*, evaluated at *value*. Returns the probability that a normal random variable is greater than *value* for a normal distribution. (The variance is the square of the standard deviation.)<br><br>`UTPN` (*mean*, *variance*, *value*) |
| **UTPT** | Upper-Tail Student's t Probability given *degrees* of freedom, evaluated at *value*. Returns the probability that the Student's t random variable is greater than *value*.<br><br>`UTPT` (*degrees*, *value*) |

**Real-Number Functions** Some real-number functions can also take complex arguments.

| | |
|---|---|
| **CEILING** | Smallest integer greater than, equal to *value*.<br>`CEILING(`*value*`)` |
| **DEG→RAD** | Degrees to radians. Converts *value* from Degrees angle format to Radians angle format.<br>`DEG→RAD(`*value*`)` |
| **FLOOR** | Greatest integer less than or equal to *value*.<br>`FLOOR(`*value*`)` |
| **FNROOT** | Function root-finder (like Solver aplet). Finds the value for the given *variable* at which *expression* most nearly evaluates to zero. Uses *guess* as initial estimate.<br>`FNROOT(`*expression, variable, guess*`)` |
| **FRAC** | Fractional part.<br>`FRAC(`*value*`)` |
| **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).<br>`HMS→(` *H.MMSSs*`)` |
| **→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).<br>`→HMS(`*x.x*`)` |
| **INT** | Integer part.<br>`INT(`*value*`)` |
| **MANT** | Mantissa (significant digits) of *value*.<br>`MANT(`*value*`)` |

## Real-Number Functions, continued

**MAX** Maximum. The greater of two values.

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

**MIN** Minimum. The lesser of two values.

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

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

*value1* `MOD` *value2*

**%** $x$ percent of $y$; that is, $xy/100$.

`%(`$x$`,`$y$`)`

**%CHANGE** Percent change from $x$ to $y$, that is, $100(y-x)/x$.

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

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

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

**RAD→DEG** Radians to degrees. Converts *value* from one angle format to another.

`RAD→DEG (`*value*`)`

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

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

**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 $\left(\frac{x}{\sqrt{x^2+y^2}}, \frac{y}{\sqrt{x^2+y^2}}\right)$

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

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

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

**XPON** Exponent of *value*.

`XPON(`*value*`)`

**Statistics-Two** These are functions for use with two-variable statistics. See chapter 5, Statistics.

**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 (■ [**CHARS**]) as well as the MATH menu.

| | |
|---|---|
| **= (*equals*)** | Sets an equality for an equation. This is *not* a logical operator. (See the Test category.)<br><br>*expression1=expression2* |
| **ISOLATE** | Isolates the first occurrence of *variable* in *expression* and returns an equation, *variable=value*. 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.<br><br>`ISOLATE(`*expression*`,`*variable*`)` |
| **LINEAR?** | Tests whether *expression* is linear for the specified *variable*. Returns `0` (false) or `1` (true).<br><br>`LINEAR?(`*expression*`,`*variable*`)` |
| **QUAD** | Solves quadratic *expression* for *variable* and returns an equation, *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 − .<br><br>`QUAD(`*expression*`,`*variable*`)` |
| **QUOTE** | Encloses an expression that should not be evaluated numerically.<br><br>`QUOTE(`*expression*`)` |
| **\| (*where*)** | Evaluates *expression* where each given variable is set to the given *value*. Allows numeric evaluation of a symbolic expression.<br><br>*expression* \| `(`*variable1=value1,variable2=value2,...*`)` |

**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.<br>*value1*<*value2* |
| ≤ | Less than or equal to. Returns 1 if true, 0 if false.<br>*value1*≤*value2* |
| == | Equals (logical test). Returns 1 if true, 0 if false.<br>*value1*==*value2* |
| ≠ | Not equal to. Returns 1 if true, 0 if false. ≠<br>*value1*≠*value2* |
| > | Greater than. Returns 1 if true, 0 if false.<br>*value1*>*value2* |
| ≥ | Greater than or equal to. Returns 1 if true, 0 if false.<br>*value1*≥*value2* |
| **AND** | Compares *value1* and *value2*. Returns 1 if they are both non-zero, otherwise returns 0.<br>*value1* `AND` *value2* |
| **IFTE** | If *expression* is true, do the *trueclause*; if not, do the *falseclause*.<br>`IFTE(`*expression*`,` *trueclause*`,` *falseclause*`)`<br>Example: `IFTE(X>0,`$X^2$`,`$X^3$`)` |
| **NOT** | Returns 1 if *value* is zero, otherwise returns 0.<br>`NOT` *value* |
| **OR** | Returns 1 if either *value1* or *value2* is non-zero, otherwise returns 0.<br>*value1* `OR` *value2* |
| **XOR** | Exclusive OR. Returns 1 if either *value1* or *value2* –but not both of them–is non-zero, otherwise returns 0.<br>*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 (all these functions have keys).

| | |
|---|---|
| **ACOT** | Arc cotangent. |
| | ACOT(*value*) |
| **ACSC** | Arc cosecant. |
| | ACSC(*value*) |
| **ASEC** | Arc secant. |
| | ASEC(*value*) |
| **COT** | Cotangent : cos*x*/sin*x*. |
| | COT(*value*) |
| **CSC** | Cosecant : 1/sin*x* |
| | CSC(*value*) |
| **SEC** | Secant : 1/cos*x*. |
| | SEC(*value*) |

# 3

# Plotting and Exploring Functions

**Types of Plots** Graphing is at the heart of the HP 38G. All of the built-in aplets do graphing. This chapter considers the four main built-in aplets:

- Function,
- Parametric,
- Polar, and
- Sequence.

The Solve aplet and Statistics aplet, which also include graphing, are covered in separate chapters.

## Defining a Problem

You start with an aplet and a mathematical function to explore, like $y = mx + b$.

**General Steps**

1. From the Library ([LIB]), open the aplet you want. This determines the type of function you can enter and plot.
2. In the Symbolic view ([SYMB]), enter or select an expression. Check the angle units in the Symbolic Setup (■ [SETUP-SYMB]).
3. In the Plot view ([PLOT]), display the graph. There are menu keys to explore by tracing and zooming. Optional : Specify graph settings in the Plot Setup (■ [SETUP-PLOT]).
4. Explore a table of numeric values in the Numeric view ([NUM]). Optional : specify table settings in the Numeric Setup (■ [SETUP-NUM]).
5. *All information is automatically stored* until you change it. To preserve the complete aplet as you have set it up, use the Library to name and save the aplet (chapter 1).

## Select an Aplet

Select the aplet appropriate to your problem : Open the Library ([LIB]), highlight the name of an aplet, and press {{START}} (or [ENTER]).

- **Function** . This aplet can define rectangular equations of the form $y = f(x)$ .
- **Parametric** . This aplet can define parametric expressions, which define equations over time, $t$. They take the forms $x = f(t)$ and $y = g(t)$.
- **Polar** . This aplet can define polar expressions, which graph equations in terms of an angle $\theta$.
- **Sequence** . This aplet can define sequence functions, which are defined in terms of $n$ or in terms of the previous terms in the sequence. Sequence plotting produces either *stairstep* graphs $(n, U_n)$ or *cobweb* graphs $(U_{n-1}, U_n)$.
- **Other aplets** . You can load or create other aplets besides those that are built in. Those you create yourself will be based on an existing aplet, filled with data and then named (if you like).

## Define an Expression (Symbolic View)

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

You can define up to ten different functions for each Function, Parametric, Polar, and Sequence aplets. You can graph any number of functions (in the same aplet) simultaneously by checkmarking them.

**To define the expression**

1. Display the Symbolic view ([SYMB]). If the highlight is on an existing expression, scroll to an empty line—unless you don't mind writing over the expression. Or, clear one line ([DEL]) or all lines (■ [CLEAR]).
2. Make sure your function is in the form "$y =$ ". For example, given the equation $9x + y - 11 = 0$, you would rearrange it to $y = f(x) = -9x + 11$. Type in just the expression $(-9x+11)$ for the right side.
   - **For a Function definition**, enter an expression to define F(X). The only independent variable in the expression is X.
   - **For a Parametric definition**, enter a pair of expressions to define X(T) and Y(T). The only independent variable in the expressions is *T*.
   - **For a Polar definition**, enter an expression to define R(θ). The only independent variable in the expression is θ.
   - **For a Sequence definition**, enter the first, second, and *n*th terms for U (U1, or...U9, or U0). Define a sequence function 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.
3. Press [ENTER] or {{OK}} to enter the expression into the list. *All checkmarked expressions will be plotted.*

**Symbolic View Keys**

| Key | Meaning |
|---|---|
| {{EDIT}} | Copies the highlighted expression to the edit line for editing. Press {{OK}} when done. |
| {{✓CHK}} | Checks/unchecks the current expression (or set of expressions). Only the checked expression(s) are evaluated in the Plot and Numeric views. |
| {{X}}, {{T}}, {{θ}}, {{N}} | Typing aids for the independent variable. Or, you can use the [XTθ] key on the keyboard. |
| {{U1}}...{{U9}} {{U0}} {{(N−1)}} {{(N−2)}} | Additional typing aids for variables in the Sequence aplet. |
| {{SHOW}} | Displays the current expression in standard mathematical form. |
| {{EVAL}} | Symbolically evaluates the variables of the current expression. |
| [VAR] [MATH] | Menus for entering variable names, contents of variables, or math operations. |
| ■ [CHARS] | Displays special characters. To type one, place the cursor on it and press {{OK}}. |
| [DEL] | Deletes the highlighted expression *or* the current character in the edit line. |
| ■ [CLEAR] | Deletes all expressions in the list *or* clears the edit line (if it was in use). |

**Angle Measure Setup**

For the Function, Parametric, Polar, and Sequence aplets, the only setting for the Symbolic view is the angle measure. This is significant only if any trigonometric function is used.

To check or change the angle measure, press ■ **[SETUP-SYMB]**. The choices are Radians, Degrees, and Grads. *This setting can affect what the graph looks like, as well as what the numerical values are.*

# Evaluating Expressions

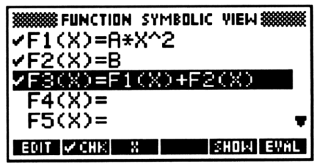
**In Aplets**

In the Symbolic view, a variable is a symbol only, and does not represent one specific value.

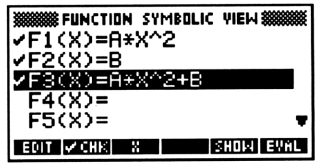
If a variable contains another variable in it, then {{EVAL}} substitutes it as shown in this example.

*In Function Symbolic view, enter these three expressions.*

*Highlight F3.*




{{EVAL}}




**In Home**

You can also evaluate any expression in Home by entering it into the edit line and pressing ENTER. For example, in Home type `F3(X)` ENTER to evaluate the above expression . This will fully evaluate the expression, substituting any stored values for A and B and X.

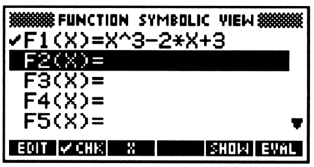
## Examples : Defining Expressions

**Function Example**

Define $x^3 - 2x + 3$.
Enter this expression as the right side of the equation in the Symbolic view.

In the Symbolic view of the Function aplet, highlight a line (or clear the lines) and enter the expression.

[LIB] *Select* **Function**
{{START}}
{{X}} [$x^y$] 3 [-] 2 [*] {{X}} [+]
3 [ENTER]




Remember that the equation that the HP 38G evaluates must be in the form $f(x)$ = *expression in terms of x.*

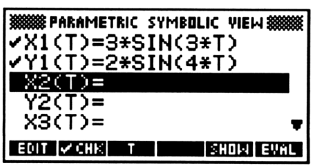
| Given this expression... | Rearrange it to... | And enter... |
|---|---|---|
| $3x + 2y - 4 = 0$ | $y = -3/2x + 2$ | `-3/2*X+2` |
| $x^2 + 7x + 10 = 0$ | $y = x^2 + 7x + 10$ | `X^2+7*X+10` |
| $x^2 = 2x + 7$ | $y_1 = x^2$<br>$y_2 = 2x + 7$<br>$y_3 = y_1 - y_2$ | `F1(X)=X^2,`<br>`F2(X)=2*X+7,` and<br>`F3(X)=F1(X)-F2(X)` |

**Parametric Example**

Define $x(t) = 3\sin 3t$
$y(t) = 2\sin 4t$.

In the Symbolic view of the Parametric aplet, highlight a line (or clear the lines) and enter the expressions.

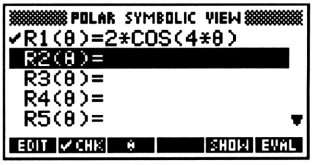
[LIB] *Select* **Parametric**
{{START}}
3 [*] [SIN] 3 [*] {{T}} [ENTER]
2 [*] [SIN] 4 [*] {{T}} [ENTER]



**Polar Example** Define $r = 2\cos 4\theta$.

In the Symbolic view of the Polar aplet, highlight a line (or clear the lines) and enter the expression.

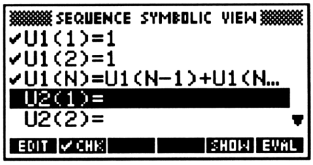
[LIB] *Select* **Polar**
{{START}}
2 [*] [COS] 4 [*] {{θ}}
[ENTER]




**Sequence Example** Define the Fibonacci sequence, in which each term (after the first two) is the sum of the preceding two terms :
$f_1 = 1, f_2 = 1$, and $f_3 = f_{n-1} + f_{n-2}$ for $n \geq 3$.

In the Symbolic view of the Sequence aplet, highlight a line (or clear the lines) and enter the expressions.

[LIB] *Select* **Sequence**
{{START}}
1 [ENTER] 1 [ENTER]
{{U1}} {{(N−1)}} [+]
{{U1}}{{(N−2)}} [ENTER]




# Plotting

## Plot the Expression (Plot View)

After entering and selecting (checkmarking) 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 Setup (page 3-18).

**Comparing Plots** You can plot up to ten expressions at the same time. Simply checkmark all those expressions you want to be plotted together.

**Pausing a Plot** Press {{PAUSE}} or [ON] to interrupt plotting. Press {{CONT}} to continue plotting. Press [PLOT] to start the plotting over.

**Erasing a Plot** Press ■ [CLEAR] to erase a plot.

**Undefined Points** If, during plotting, a real value for the expression is not found, then that point is not plotted, and no line is connected through it.

**Tracing a Plot** When a graph is newly drawn, TRACE mode is on. Pressing a cursor key will trace the crosshairs along the graph, displaying the coordinate values as they move.

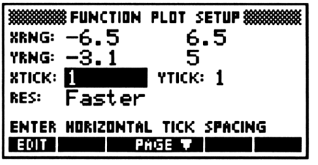
**Scrolling a Plot** In Function and Sequence aplets, you can scroll left and right beyond the edge of the window to see more of the graph.

**Zooming** Press [PLOT]{{ZOOM}} for a choice of zooming options. To switch to a predefined axis scaling (such as Trig or Integer), press ■ [VIEWS].

## Examples : Plotting

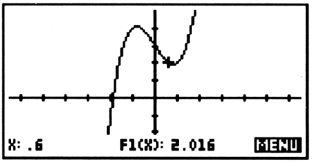
**Function Example** Plot the expression from the previous Function example, $x^3 - 2x + 3$. In Plot Setup, specify `YRNG : -3.1 5` so that you can see more of the graph (the default values are −3.1 and 3.2). You can leave the other plot settings at their default values.

[LIB] *Select* **Function**
{{START}}
*Make sure the correct function is highlighted and checked.*
■ [SETUP-PLOT]
[▼] [▶] 5 [ENTER]



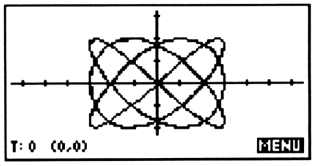

[PLOT]
[▶] *6 times*

(The cursor starts in the center of the X-range and traces the plot.)



**Parametric Example**

Plot the expressions from the previous Parametric example, $x(t) = 3\sin 3t$ and $y(t) = 2\sin 4t$. Before plotting, however, reset the default plot settings by clearing the Plot Setup view.

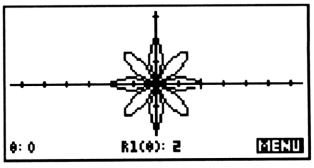



LIB *Select* **Parametric**
{{START}}
*Make sure the correct function is highlighted and checked.*
■ [SETUP-PLOT]
■ [CLEAR]

PLOT

**Polar Example**

Plot the expression from the previous Polar example, $r = 2\cos 4\theta$. Before plotting, however, reset the default plot settings by clearing the Plot Setup view.




LIB *Select* **Polar**
{{START}}
*Make sure the correct function is highlighted and checked.*
■ [SETUP-PLOT]
■ [CLEAR]

PLOT

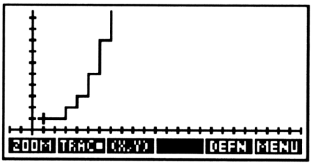
**Sequence Example**

Plot the Fibonacci sequence from the previous Sequence example, $U_1 = 1$, $U_2 = 1$, and $U_n = U_{n-1} + U_{n-2}$. In Plot Setup, first set the SEQPLOT to Stairstep, then try a Cobweb plot. Reset the default plot settings by clearing the Plot Setup view.

- A **Stairstep** 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.

[LIB] *Select* **Sequence**
{{START}}
*Make sure the correct function is highlighted and checked.*
■ [SETUP-PLOT]
■ [CLEAR]

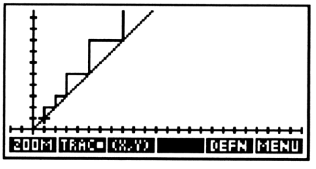

[PLOT]




Now set SEQPLOT to Cobweb and see the difference.

■ [SETUP-PLOT]
{{CHOOS}}
*Select* **Cobweb**

[PLOT]



# Exploring the Plot

Plot view (press PLOT or ■ [VIEWS]) gives you a selection of menu keys to explore a graph further (for the checkmarked expressions in the Symbolic view). *The options vary from aplet to aplet.*

**PLOT View Keys**

| Key | Meaning |
|---|---|
| ■ [CLEAR] | Erases the plot. |
| ■ [VIEWS] | Offers additional pre-defined views for splitting the screen and for scaling ("zooming") the axes. |
| ■ ◀<br>■ ▶ | Moves cursor to *far left* or *far right.* |
| {{ZOOM}} | Displays ZOOM menu list. |
| {{TRACE}} | Turns Trace mode on/off. The ■ appears when Trace mode is on ({{TRAC■}}). |
| {{(X,Y)}} | Displays the cursor's coordinate position. Press {{MENU}} to restore the menu. |
| {{FCN}} | Function aplet only: Turns on menu list for root-finding functions (*see "Interactive Root-Finding," later in this chapter*). |
| {{DEFN}} | Displays the current, *defining* expression. Press {{MENU}} to restore the menu. |
| {{MENU}} | Turns menu-key labels on and off. When the labels are off, any top-row key turns them back on. |

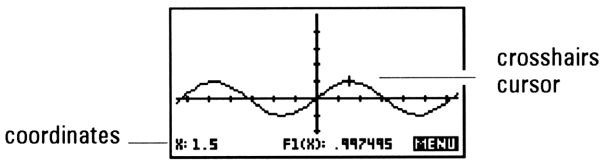
## Tracing

Many aplets have a Trace mode. Trace mode is on when a plot has just been drawn. When Trace mode is on, the crosshairs cursor follows just the plotted points when you press the ◀ or ▶ keys. The cursor *traces* the function. The display also shows the current coordinate position (*x*, *y*) of the cursor.

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

Note that 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 turn on TRACE mode**

- Trace mode *and* the coordinate display are automatically set when a plot is drawn. At other times, set Trace mode by pressing {{TRACE}} to change the label to {{TRAC■}}. (If the menu labels are not displayed, press {{MENU}} first.)
- Turn off Trace mode by changing the menu label back to {{TRACE}}.

**To turn on coordinates**

- To turn on the display of the coordinates' values at the current cursor position, press {{(X,Y)}}. To turn the coordinate display off again, press {{MENU}}.

## Zooming

One of the menu key options in PLOT is {{ZOOM}}. Zooming redraws the plot on a larger or smaller scale, or on a heightened or widened scale. It is a shortcut for changing the Plot Setup, and it does change those settings.

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

*Not all* ZOOM *options are available in all aplets.*

**{{ZOOM}} Options**

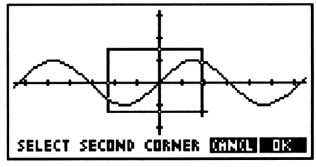
Select an option and press {{OK}}.

| Option | Meaning |
|---|---|
| **Center** | Recenters the plot around the current position of the crosshairs *without* changing the scale. |
| **Box...** | Lets you draw a box to define the zoom boundaries. Use the cursor keys to draw the box, and press {{OK}} to zoom in (see below). |
| **In** | Divides horizontal and vertical scales by the X-factor and Y-factor (in Set Factors, below). For instance, if zoom factors are 4, then zooming in results in 1/4 as many units depicted per pixel. |
| **Out** | Multiplies horizontal and vertical scales by the X-factor and Y-factor (in Set Factors, below). |
| **X-Zoom In** | Divides horizontal scale only, using X-factor. |
| **X-Zoom Out** | Multiplies horizontal scale only, using X-factor. |
| **Y-Zoom In** | Divides vertical scale only, using Y-factor. |
| **Y-Zoom Out** | Multiplies vertical scale only, using Y-factor. |
| **Square** | Changes the vertical scale to match the horizontal scale. |
| **Set Factors...** | Sets the X-Zoom and Y-Zoom factors for zooming (multiplying for Zoom Out, dividing for Zoom In). Includes option to recenter the plot before zooming. |
| **Un-zoom** | Returns the display to the previous zoom. |

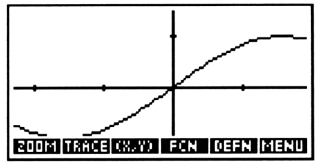
**To use Box Zoom**

The Box Zoom option lets you draw a box around the area you want to zoom in on.

1. If necessary, press {{MENU}} to turn on the menu-key labels.
2. Press {{ZOOM}} and select `Box...`
3. Position the crosshairs into one corner of the box-to-be. Press {{OK}}.
4. Use the cursor keys (▼, etc.) to drag two sides of a box.




5. Press {{OK}} to zoom in on the boxed area.



## Other Views for Scaling and Splitting the Graph

**Other Scales**

The preset viewing options (■ [VIEWS]) draw the plot using certain pre-defined axis scales. This is a shortcut for changing Plot Setup. For instance, if you have defined a trigonometric function, then you could select `Trig` to plot your function on a trigonometric scale.

**[VIEWS] Options**

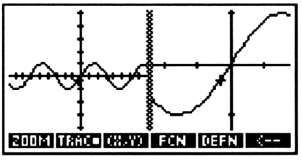
Select an option and press {{OK}}.

| Option | Meaning |
|---|---|
| **Plot-Detail** | Splits the screen into the plot and a close-up (see the next topic). |
| **Plot-Table** | Splits the screen into the plot and the data table (see page 3-24). |
| **Overlay Plot** | Plots the current expression(s) *without* erasing any pre-existing plot(s). |
| **Auto Scale** | Rescales the axes using autoscaling. |
| **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.) |
| **Integer** | Rescales horizontal axis only, making each pixel =1 unit.(Not in Sequence or Statistics.) |
| **Trig** | Rescales horizontal axis so 1 pixel =π/24 radian, 7.5°, or 8.$^{1}/_{3}$ grads; rescales vertical axis so 1 pixel=0.1 unit. (Not in Sequence or Statistics.) |

**Splitting the Screen**

The Split Screen 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}} to choose 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).
   - ■ [◀] or ■ [▶] moves the cursor to the far left or far right of the full plot.
   - The {{<--}} left-arrow menu key will convert the base plot (left side) to the scale of the zoomed plot (right side). (It does so by resetting the variables' minimum and maximum values in the Plot Setup.)
3. To un-split the screen, press [PLOT]. The left side takes over the whole screen.

**Overlaying Plots**

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

# Setting Up the Plot (Plot Setup)

Press ■ [SETUP-PLOT] to define any of the settings shown in the next two tables.

1. Use the arrow keys to move from field to field. 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 display and select the different choices.
   - If there is an option to turn on/off, press {{√CHK}} to check or uncheck it.
2. Press {{PAGE▼}} to view more settings.
3. When done, press [PLOT] to view the new plot.

**To reset settings**

To reset the default values for all plot settings, press ■ [CLEAR] in the Plot Setup view.

**[SETUP-PLOT] Settings**

| Field | Meaning |
|---|---|
| XRNG, YRNG , TRNG , θRNG, NRNG | **For Function plot:** Specifies the minimum and maximum horizontal (X) and vertical (Y) values for the plotting window. |
| | **For Parametric, Polar, and Sequence plots:** Specifies the time (T), angle (θ), or index (N) values for the graph. |
| RES | **For Function plots**: Resolution. "Faster" plots in alternate pixel columns; "More Detail" plots in every pixel column. |
| TSTEP , θSTEP | **For Parametric and Polar plots**: intervals at which to use the independent variable to calculate the function. |
| SEQPLOT | **For Sequence plots**: Stairstep or Cobweb types. |
| XTICK | Horizontal spacing for tickmarks. |
| YTICK | Vertical spacing for tickmarks. |

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

| | |
|---|---|
| SIMULT | If more than one function is being plotted, plot them simultaneously (otherwise sequentially). |
| INV. CROSS | When the crosshairs cross the plot, invert those pixels that are overlapping. |
| CONNECT | Connect the plotted points. (Sequence 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. |

## Interactive Root-Finding

You can find roots, intersections, slopes, and areas for a function in the Plot view of the Function aplet (and any Function-based aplets). The {{FCN}} operations act on the currently selected expression or on the graph being traced.

The results are saved in the variables Area, Extremum, Isect, Root, and Slope, so you can do further calculations with these results in the aplet or in Home.

**To use a {{FCN}} operation**

1. In Symbolic view in a Function aplet, select the expression (for Intersect, *two* expressions) whose curve you want to study. Or trace the curve you want to study.
2. Position the cursor where you want it to be before pressing {{FCN}}. If you cannot see the crosshairs, they might be on the axes. Press ◀ or ▶ to move the cursor and make it visible.
3. Press {{FCN}}, then select an operation from the menu list and press {{OK}}.
4. To perform another operation, press {{MENU}} to turn the menu-key labels back on.

**To move the cursor** To change the starting position of the cursor after having selected an operation, press {{MENU}}, move the cursor, and re-select the FCN operation.

**To clear shading** To remove the shading produced by the AREA operation, press [PLOT] to re-draw the plot.

## FCN Operations

**Root** Select `Root` to find the root *x*-value nearest the crosshairs. If no root is found, but only an extremum, then the result is labeled `EXTR:` instead of `ROOT:`. (The root-finder is also used in the Solve aplet. See also "Interpreting Results," in chapter 4.) The resulting *x*-value is saved in a variable named Root.

**Extremum** Select `Extremum` to find the maximum or minimum nearest the crosshairs. This displays the coordinate values and moves the crosshairs to the extremum. (This uses the derivative.) The resulting value is saved in a variable named Extremum.

**Slope** Select `Slope` to find the numeric derivative at the point nearest the crosshairs. The result is saved in a variable named Slope.

**Area** Select `Area` to find the numeric integral. (If there are two or more expressions checkmarked, then you will be asked to choose the second expression from a list that includes the *x*-axis.) Select a starting point, then move the cursor to shade a region between the curve and the *x*-axis (or another curve), and between the starting point and the current position. The shaded region will be between the two curves. The Area is the *signed* value of the shaded area. Areas below the *x*-axis are *negative*. The result is saved in a variable named Area.

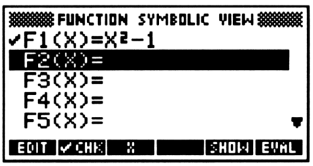
**Intersection** Select `Intersection` to find the intersection of two graphs nearest the crosshairs. *(You need to have at least two selected expressions in Symbolic view.)* Displays the coordinate values and moves the crosshairs to the intersection. (Uses Solve function.) The resulting *x*-value is saved in a variable named Isect.

## Examples : Root-Finding with Plots

These examples of the interactive root-finding operations use the expression $f(x) = x^2 - 1$ in the Function aplet with default plot settings.

*Select the Function aplet.*

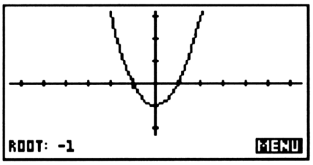
SYMB
{{X}} ■ [$x^2$] − 1 ENTER




**ROOT**

■ [SETUP-PLOT]
■ [CLEAR]

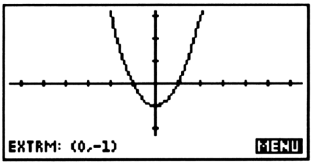
PLOT
{{MENU}} {{FCN}}
*Select* **Root** {{OK}}




The crosshairs started at (0, −1). The root nearest the crosshairs is $x = -1$. The crosshairs have moved to (−1,0).

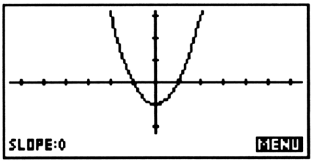
**EXTREMUM**

{{MENU}} {{FCN}}
*Select* **Extremum** {{OK}}




**SLOPE**

{{MENU}} {{FCN}}
*Select* **Slope** {{OK}}

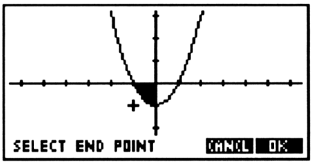



The slope at the extremum (where the crosshairs are) is zero.

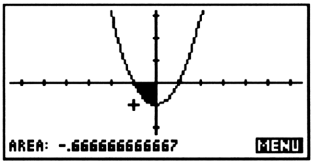
**AREA**

You move the cursor to the starting point first, then shade the area.

{{MENU}} {{FCN}}
*Select* **Area...** {{OK}}
{{OK}} *to set starting point*
◀ *10 times*




{{OK}}

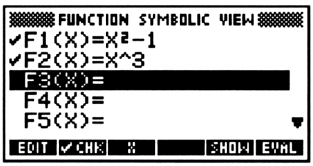



The shaded area has a value of −0.666666666667 (to 12-digit accuracy). It is negative because the region lies below the *x*-axis.

Enter a second expression, $f(x) = x^3$, in Function aplet, and find the intersection of it with $f(x) = x^2 - 1$.

*Select the Function aplet.*

SYMB
{{X}} $x^y$ 3 ENTER

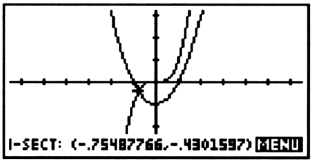



**INTERSECT**

You must specify whether to find the intersection with the second function or with the *x*-axis.

PLOT {{MENU}} {{FCN}}
*Select* **Intersection**
{{OK}}

*Select the function F(X)=X^3 (not the x-axis)* {{OK}}.



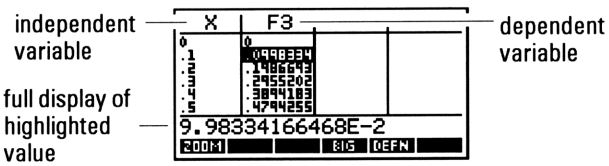
# Using a Table of Numbers

## Display a Table of Numbers (Numeric View)

After entering and selecting (checkmarking) the expression in the Symbolic view, press NUM to view a table of data values for the **independent** (**X, T, θ,** or **N**) and dependent variables. To adjust the initial value or step size, change the Numeric Setup.

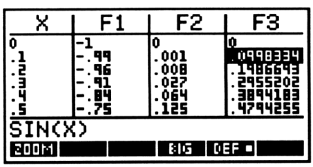
**NUM View Keys**

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




The table adds columns for each additional expression that is checkmarked in the Symbolic view.

Press {{DEFN}} to display the expression that defines the function in the highlighted column.




**Automatic Recalculation**

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

# Exploring the Table of Numbers

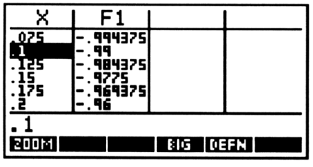
**Zooming**

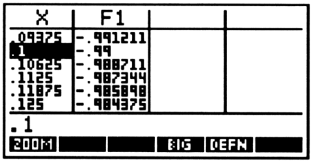
Zooming redraws the table of numbers in greater or lesser detail.

**{{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 unit. Starts at zero. (Shortcut to changing NUMSTART and NUMSTEP.) |
| **Integer** | Changes intervals for the independent variable to 1 unit. Starts at zero. (Shortcut to changing NUMSTEP.) |
| **Trig** | Changes intervals for independent variable to $\pi/24$ radian or 7.5 degrees or $8^{1}/_{3}$ grads. Starts at zero. |
| **Un-zoom** | Returns the display to the previous zoom. |

The display on the right is a Zoom In of the display on the left.

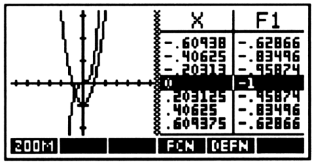


**Splitting the Screen**

The Split Screen view gives you two simultaneous views.

1. In the Symbolic view of the appropriate aplet, make sure the function(s) you want are checkmarked.
2. Press ■ [VIEWS]. Select `Plot-Table` and press {{OK}}.




3. The ◄ and ► cursor keys move the crosshairs along the plot; the view of the table adjusts itself. The ▲ and ▼ cursor keys move the crosshairs from one graph to another.
4. To return to a full Numeric (or Plot) view, press NUM (or PLOT).

## Setting Up the Table (Numeric Setup)

Press ■ [SETUP-NUM] to define any of the settings shown in the table below. To reset the default values for all table settings, press ■ [CLEAR].

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

**To reset settings**

To reset the default values for all table settings, press ■ [CLEAR].

**SETUP-NUM Screen**

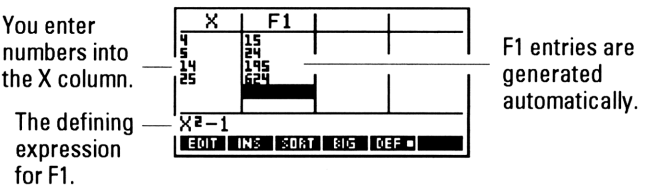
| Field | Meaning |
|---|---|
| NUMSTART | Where to start the independent variable's first value. |
| NUMSTEP | The size of the increment from one independent variable value to the next. |
| NUMTYPE | Type of numeric table : Automatic or Build Your Own. To build your own table, you must type each independent value into the table yourself. |
| NUMZOOM | Zoom factor (multiplies the scale for Zoom Out, divides for Zoom In). |

## Building Your Own Table of Numbers

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

**To format a table**

1. Start with an expression defined (in Symbolic view) in the aplet of your choice.
2. In the Numeric Setup (■ [SETUP-NUM]), choose `NUMTYPE: Build Your Own`.
3. Open the Numeric view ([NUM]). To clear existing data in the table, press ■ [CLEAR].
4. Enter the independent values in the left-hand column. Type in the 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}}.



**To clear data** Press ■ [CLEAR] to erase the data from a table.

**"Build Your Own" Keys**

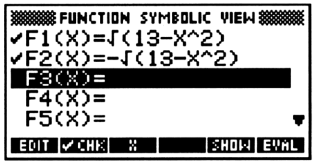
| Key | Meaning |
|---|---|
| {{EDIT}} | Puts the highlighted independent value (X, T, Θ, or N) into the edit line. After you edit the number, press [ENTER]. |
| {{INS}} | Inserts a row of zero values at the position of the highlight. Replace the zero by typing the number you want and pressing [ENTER]. |
| {{SORT}} | Automatically rearranges the left-hand column into values in ascending (getting larger) or descending (getting smaller) order. |
| {{BIG}} | Toggles between two character sizes. |
| {{DEFN}} | Displays the defining function expression for the highlighted column. |
| [DEL] | Deletes the highlighted row. |
| ■ [CLEAR] | Clears *all* data from the table. |

# More Examples

**Function Example**

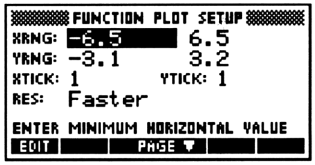
Plot the circle, $x^2 + y^2 = 13$. Rearrange the equation to $y = \pm\sqrt{(13 - x^2)}$. This must be entered as two expressions, $y = \sqrt{(13 - x^2)}$ and $y = -\sqrt{(13 - x^2)}$

[LIB] *Select* **Function**
[SYMB]
[√x] [(] 13 [-] {{X}} [x^y] 2 [)]
[ENTER]
[-x] [√x] [(] 13 [-] {{X}} [x^y] 2 [)] [ENTER]

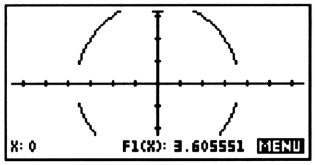



■ [SETUP-PLOT]

*(Check that the Plot settings are the defaults–if not, press* ■ [CLEAR].*)*

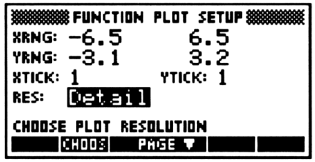



[PLOT]



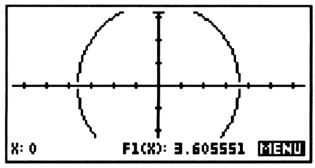

The calculator plots the two expressions of the conic plot separately, sometimes producing a discontinuity in the graph. Specify a finer resolution to minimize these discontinuities. (The gaps are due to the sampling interval.)

■ [SETUP-PLOT]
[▼] [▼] [▼] {{CHOOS}}
*Select* **More Detail**



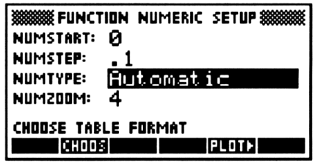
**Function Example, continued**

PLOT

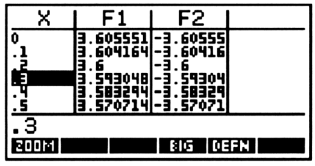



■ [SETUP-NUM]

*(Check that the Numeric settings are the defaults—if not, press* ■ [CLEAR]*.)*



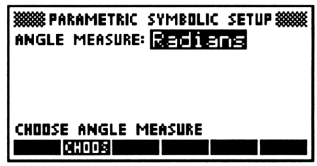

NUM



**Parametric Example**

Plot the two sets of equations below that describe the paths of two particles over time. Look at the interval between $t = 0$ and $t = 6.5$ seconds.

LIB *Select* **Parametric**
■ [SETUP-SYMB]
*Check that* **Radians** *is set.*

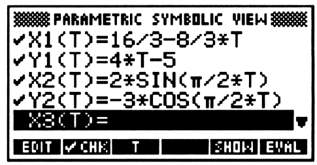



SYMB 16 / 3 − 8 / 3 * {{T}} ENTER

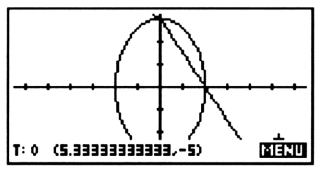
4 * {{T}} − 5 ENTER

2 * SIN ■ [π] / 2 * {{T}} ENTER

-x 3 * COS ■ [π] / 2 * {{T}} ENTER



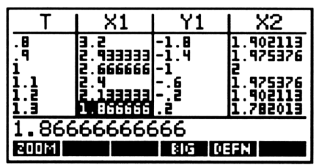

PLOT




Use the Numeric view to determine whether the particles ever collide (that is, whether their paths cross at the same moment in time). Compare the T values when X1=X2 and when Y1=Y2. You can tell from the plot that the points of intersection are at or near X=2 and Y=3. If T is the same at these points, then the points collide.

NUM

*Search for X1=2 and X2=2.*
*Move the highlight to* X1=1.866666.




You can see that X2=2 when T=1. Use ZOOM to home in on X1=2.

**Parametric Example, continued**

{{ZOOM}} *Select* **In** {{OK}}

▲▲

| T | X1 | Y1 | X2 |
|---|---|---|---|
| 1.175 | 2.2 | -.3 | 1.924910 |
| 1.2 | 2.133333 | -.2 | 1.902113 |
| 1.225 | 2.066666 | -.1 | 1.876382 |
| 1.25 | 2 | 0 | 1.847759 |
| 1.275 | 1.933333 | .1 | 1.816286 |
| 1.3 | 1.866666 | .2 | 1.782013 |

1.99999999999

ZOOM | | | BIG | DEFN

You can now see that X1=2 when T=1.25, so the particles do not collide at X=2.

Now search for Y1=3 and Y2=3. You can use {{ZOOM}} **Out** to move more quickly through the columns, but {{ZOOM}} **In** again to find Y1=Y2=3.

▶▶▶ *to highlight the Y2 column*

▼... *to highlight Y2=3*

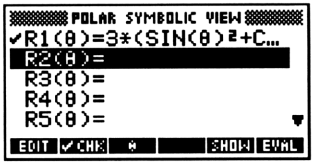
| T | Y1 | X2 | Y2 |
|---|---|---|---|
| 1.875 | 2.5 | .3901806 | 2.942356 |
| 1.9 | 2.6 | .3128689 | 2.963065 |
| 1.925 | 2.7 | .2350748 | 2.979205 |
| 1.95 | 2.8 | .1569182 | 2.990752 |
| 1.975 | 2.9 | .0785196 | 2.997687 |
| 2 | 3 | -2E-11 | 3 |

3

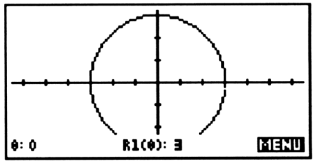
ZOOM | | | BIG | DEFN

Since Y1 and Y2 intersect (when Y=3) at the same value for T, the particles collide at T=2 seconds.

**Polar Example** Plot the circle, $r = 3 (\sin^2\theta + \cos^2\theta)$.

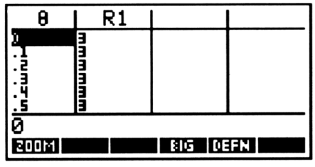



LIB *Select* **Polar**
■ [SETUP-SYMB]
*Check that* **Radians** *is set.*
SYMB 3 * ( SIN {{θ}} )
■ [$x^2$] + COS {{θ}} )
■ [$x^2$] ) ENTER




PLOT

*(If your plot does not look this, check that the Plot Setup has the default settings.)*




NUM

*(If your table does not look like this, make sure the Numeric Setup has the default settings.)*

**Sequence Example**

Generate a sequence to calculate the square root of 2 using the iterative relationship

$(U_n) \times (U_{n-1}) = \frac{1}{2}(U_{n-1}^2 + a)$, where $a = 2$.

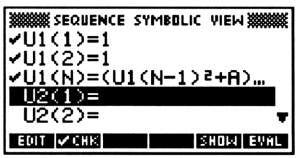
Define this sequence in the HP 38G as

U1(N) = (U1(N−1)$^2$ + A)/(2∗U1(N−1)) , and store 2 in $A$.

The Sequence aplet finds the square root by evaluating this expression with successive values of N until the value for U1 stops changing. In this case, the sequence converges at a value for $\sqrt{2}$ starting with $U_6$.

Start the sequence by setting U1(1) and U1(2) to 1.

LIB *Select* **Sequence**
{{START}}

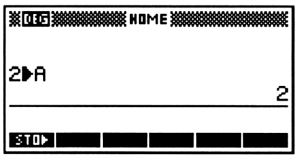



1 ENTER 1 ENTER
( {{U1}} {{N-1}} ■ [$x^2$] +
A...Z A ) / ( 2 ∗ {{U1}}
{{N-1}} ) ENTER

Store the value 2 in the real variable $A$.

HOME

2 {{STO▶}} A...Z A ENTER



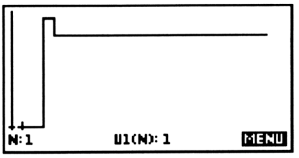

Set up a stairstep plot.

■ [SETUP-PLOT]
*Check that the default values are set, including* **Stairstep**.

*(Press* ■ [CLEAR] *to reset default values.)*

**Sequence Example, continued**

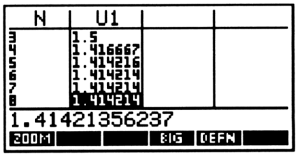
■ [VIEWS]
*Select* `Auto Scale` {[OK]}




*Explore the graph and the values for N and U1 by pressing* ◀ *and* ▶.

As you trace the graph with the cursor keys, the crosshairs jump from N:1 to N:2 to N:3, and so on. The values for U1 change by smaller and smaller amounts until they converge.

NUM

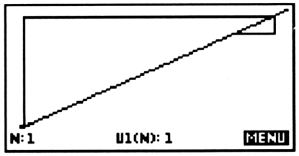



*Scroll down to see that the values for U1 remain the same for N≥6. Therefore,* $\sqrt{2}$ *is 1.41421356237 to 12 digits of accuracy.*

Compare the Stairstep plot (which plots N and U1(N)) to a Cobweb plot (which plots U1(N−1) and U1(N)). Use autoscaling for the plot. The coordinate values and the Numeric view are identical to the Stairstep plot.

■ [SETUP-PLOT] +
*Set SEQPLOT to* **Cobweb**.

■ [VIEWS]
*Select* `Auto Scale` {[OK]}

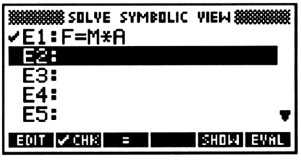


# 4

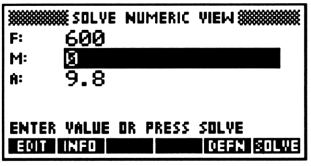
# Solve

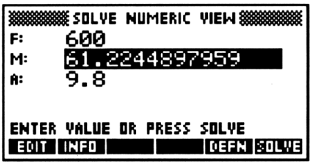
The Solve aplet will solve an equation or an expression for its *unknown variable*. You define an equation or expression in Symbolic view, then supply values for all of the variables *except one* in Numeric view. Then Solve will find the remaining unknown.

As a simple example, consider the equation *force* = *mass* × *acceleration* (that is, `F=M*A`) in the Solve Symbolic view.




If *force* is 600 N and *acceleration* is 9.8 m/sec$^2$, then pressing {{`SOLV`}} in the Solve Numeric view finds that the unknown *mass* must be 61.22 kg.




Furthermore, you can solve the equation for any one of its variables. You can solve the equation as many times as you want with new values and different unknowns.

# Solving Equations

An *equation* contains an equals sign. Its solution is a value for the unknown variable that makes both sides equal the same value.

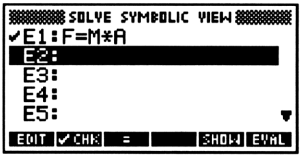
An *expression* does not contain an equals sign. Its solution is a *root*, that is, a value for the unknown variable that makes the expression equal to zero.

## Define the Equation

You can define up to ten equations (or expressions), named E0 through E9. Each equation can contain up to 27 real variables, named A through Z or θ.

**To define an equation**

1. In the Library ([LIB]), select the Solve aplet.
2. Display the Symbolic view ([SYMB]). If the highlight is on an existing equation, scroll to an empty line—unless you don't mind writing over the equation. Or, clear one line ([DEL]) or all lines ([■] [CLEAR]).
3. Enter a complete equation, including the equals sign. (The equals sign is available as a menu key.) Use only A through Z and θ as variables' names. Press [ENTER] or {{OK}} to complete the equation. *Only one equation at a time can be checkmarked.*




A Solve variable (E1 through E0) can also be defined in terms of other Solve variables. For instance, you could define E1 to be the sum of E2 and E3.

**Symbolic View Keys**

| Key | Meaning |
|---|---|
| {{EDIT}} | Copies the highlighted expression to the edit line for editing. Press {{OK}} when done. |
| {{✓CHK}} | Checks/unchecks the current expression. Only the checked expression is evaluated. |
| {{=}} | Types an equals sign into the equation. |
| {{SHOW}} | Displays the current equation in standard mathematical form. |
| {{EVAL}} | Evaluates the current equation by substituting other variables for all variables *except* the independent variable, which remains in symbolic form. |
| VAR<br>MATH | Menus for entering variable names, contents of variables, or math functions. |
| ■ [CHARS] | Displays special characters. To type one, highlight it and press {{OK}}. |
| DEL | Deletes the highlighted equation *or* the current character in the edit line. |
| ■ [CLEAR] | Deletes all equations in the list *or* clears just the edit line, if it was active. |

**Angle Setting**

The only setting for the Symbolic view is the angle measure. This is significant only if any of the equation's variables contain trigonometric functions.

To check or change the angle measure, press ■ **[SETUP-SYMB]**. The choices are Radians, Degrees, and Grads. *This setting can affect the numeric solutions, as well as the graph.*

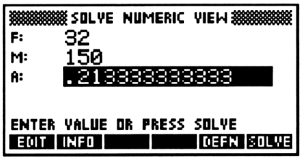
## Solve for the Unknown Variable

Assign values to all the variables except one. All of the variables must represent real values.

The unknown variable cannot be an index (as for a summation), limit (as for an integral), or placeholder variable (as for a derivative).

**To solve for an unknown**

1. Press NUM for the Numeric view. This displays all the variables and their values, if any.
2. For each variable except the unknown, type a number and press {{OK}}.
3. Move the highlight to the unknown's field and press {{SOLVE}}. The solution appears in the unknown's field.
4. You can repeat steps 2 and 3, substituting different values and selecting a different unknown each time.




If there is no solution found, or you are looking for a different solution, then you need to supply an *initial guess* (see below).

**Numeric View Keys**

| Key | Meaning |
|---|---|
| {{EDIT}} | Copies the highlighted value to the edit line for editing. Press {{OK}} when done. |
| {{INFO}} | Displays a message about the solution (see "Interpreting Results," next page). |
| {{PAGE}} | Displays other pages of variables, if any. |
| {{DEFN}} | Displays the current, defining expression. Press {{OK}} when done. |
| {{SOLVE}} | Finds the solution for the highlighted variable. |
| DEL | Clears highlighted variable to zero *or* deletes current character in edit line, if edit line was active. |
| ■ [CLEAR] | Resets all variables' values to zero *or* clears the edit line, if cursor was in edit line. |

**Using an Initial Guess**

You can obtain a faster and possibly more accurate solution if you supply an estimated value for the unknown variable *before* pressing {{SOLVE}}. Solve will look for a solution near the initial guess first.

- An initial guess is especially important in the case of a repeating, non-linear curve that could have more than one solution.
- Plot the equation to help you select an initial guess when you don't know in which range to look for the solution.

**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 "Display Modes" in chapter 1 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 time value of money. A Number Format of Fixed 2 would be appropriate in this case to handle monetary values.

# Plotting the Equation

A plot shows you graphically where the solution(s) must be :

- If you defined an expression, then the solution (root) is where the graph intersects the *x*-axis.
- If you defined an equation, then there are two graphs, one for each side of the equation. The solution is where the two graphs intersect. (If one side of the equation is constant, then one of the graphs will be a straight line.)

**To plot an equation**

1. Define the equation to solve in the Symbolic view ([SYMB]).
2. If the equation uses trigonometric functions, set the angle measure in Symbolic Setup view (■ **[SETUP-SYMB]**).
3. Enter the known variables in the Numeric view ([NUM]).
4. Highlight the independent variable in the Numeric view.
5. Press ■ **[VIEWS]** and select Auto Scale {{OK}} to plot the equation(s). Autoscaling usually gives you the best plot in Solve.

# Interpreting Results

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

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

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

| Message | Condition |
|---|---|
| **Bad Guess(es)** | No solution found. One or more of the initial guesses lie outside the domain of the equation. Therefore, the solution was not a real number or it caused an error. |
| **Constant?** | No solution found. The value of the equation is the same at every point sampled. |

**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:

```
-  -.219330555745
+  -1.31111111149
```

You can watch as the root-finder either finds a sign reversal or converges on a local minimum/maximum 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 Plot view and the Plot Setup work as they do for the Function aplet. The main reason for plotting in the Solve aplet is to help you find solutions for those equations that have difficult-to-find or multiple solutions.

**Example**

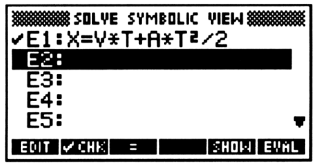
Consider the equation of motion for an accelerating body,

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

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

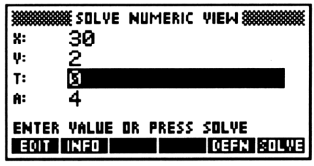
Since this equation is quadratic for $t$, there can be both a positive and a negative solution. However, we are concerned only with positive solutions, since only positive distance makes sense.

LIB *Select* **Solve**
{{START}}
A...Z **X** {{=}} A...Z **V** * A...Z
**T** + ( A...Z **A** * A...Z **T**
■ $x^2$ ) / **2** {{OK}}




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

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

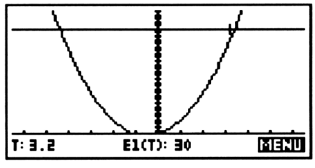



Use the Plot view to find an initial guess for T. First set appropriate X and Y ranges in the Plot Setup. Since we have an equation, $X=V*T+A*T^2/2$, the plot will produce two graphs: one for Y=X and one for $Y=V*T+A*T^2/2$. Since we have set X=30 in this example, one of the graphs will be Y=30. Therefore,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

■ [SETUP-PLOT] ▼ $-x$ **5**
ENTER **35** ENTER


PLOT

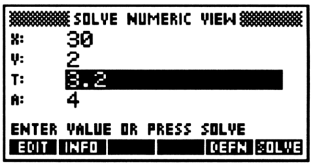
*Move the cursor near the positive (right-side) intersection. This cursor value will be an initial guess for T.*




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.

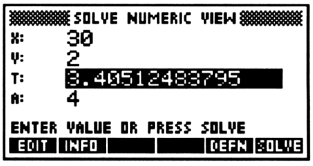
NUM

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




*Highlight the T-value.*

{{SOLVE}}




Therefore, the time it takes a body to travel 30 m when it starts at 2 m/s and accelerates at 4 $m/s^2$ is 3.40512483795 seconds (to 12 digits of accuracy).

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

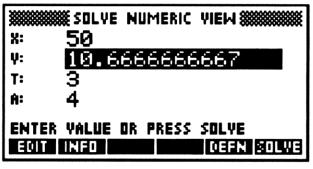
NUM

*Highlight the X value.* **50**

ENTER ▼ **3** ENTER ▲ ▲

*Highlight the V value.*

{{SOLVE}}



# About Variables

Note

**Be sure to check and define the values for all your Solve variables in the Numeric view each time you solve an equation.**

**Home Variables**

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

**Names of Variables**

All Home variables (other than those for aplet settings, like Xmin and Ytick) are *global*, which means they are *shared* throughout the different contexts 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 will show up in the Numeric view for this Solve equation. When you then redefine the value for T in this Solve equation, that value will apply to T in all other contexts (until it is changed again).

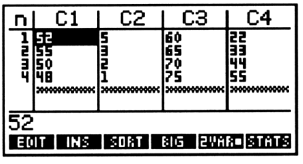
This sharing allows you to work on the same problem in different places (such as Home and Solve) without having to update the value everywhere whenever it is recalculated.

# 5

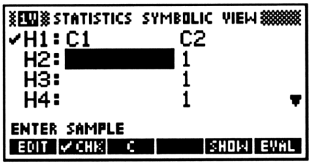
# Statistics

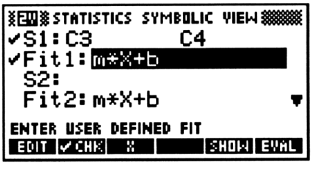
The Statistics aplet can store up to ten separate data sets at one time. It can do one-variable or two-variable statistical analyses of one or more sets of data.

- *In Numeric view*: Enter data values for one- or two-variable statistics (1VAR or 2VAR).

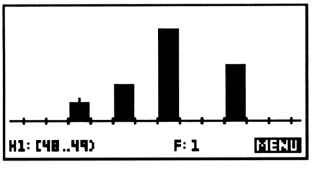


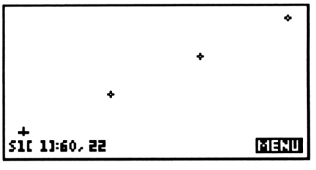

- *In Symbolic view*: Define which data columns make up a data set. The Symbolic views for one-variable (1VAR) and two-variable (2VAR) statistics are different:




- *In Plot view*: Plot one-variable data as histograms or box-and-whisker plots. Plot two-variable data as scatter plots. Two-variable data are analyzed according to one of seven different regression fits (or your own definition).



- *In Home*: You can also compute statistics values in Home and recall the values of specific statistics variables.

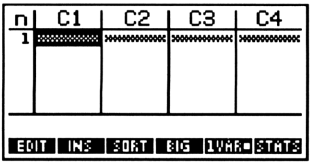
The values computed in the Statistics aplet are saved in variables, and many of these variables are listed by the {{STATS}} function in Numeric view.

# Example: Finding a Linear Equation to Fit Data

Enter and analyze the advertising and sales data below. Compute statistics, fit a curve to the data, and predict the effect of more advertising on sales.

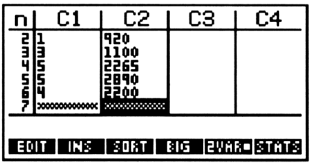
| Advertising (minutes) | Resulting Sales ($) |
|---|---|
| 2 | 1400 |
| 1 | 920 |
| 3 | 1100 |
| 5 | 2265 |
| 5 | 2890 |
| 4 | 2200 |

[LIB] *Select* `Statistics`
{{START}}
*(If necessary, use*
■ [CLEAR] *to clear two data columns)*



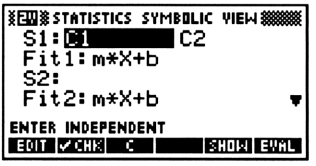

Make sure that {{2VAR■}} is on for two-variable statistics.

{{1VAR■}}
**2** [ENTER] **1** [ENTER] **3** [ENTER]
**5** [ENTER] **5** [ENTER] **4** [ENTER]
[▶] *to move to next column*
**1400** [ENTER] **920** [ENTER]
**1100** [ENTER] **2265** [ENTER]
**2890** [ENTER] **2200** [ENTER]



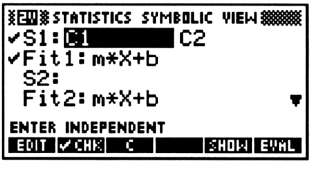

[SYMB]
*If necessary,* ■ [CLEAR] *to clear previous definition of S1.*

*Note the default Fit is Linear (mx+b).*



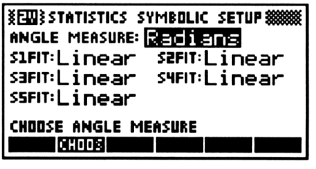

Accept the default definition for S1: C1 is the independent data and C2 is the dependent data. Select S1 by checkmarking it, if it is not already checked.

{{√CHK}}




■ [SETUP-SYMB]

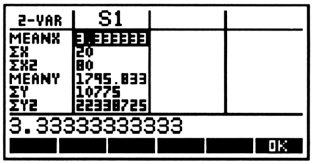
*This view lets you choose the type of Fit. If necessary, choose Linear for S1FIT.*



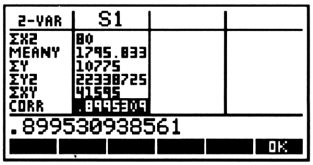
Find the mean advertising time (MEANX), the mean sales (MEANY), and the correlation coefficient (CORR) for the data fitting a straight line. The CORR value indicates how well the linear model fits the data.

NUM {{STATS}}

*Displays computed statistics. MEANX is about 3.3 minutes and MEANY is about $1796.*




*Scroll down to display CORR. CORR is 0.8995 to four significant digits.*

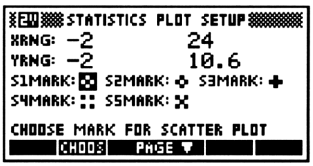



{{OK}}

■ [SETUP-PLOT] ▼ ▼

{{CHOOS}} ▼ {{OK}}

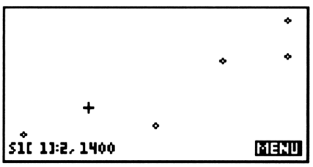
*This makes the mark for S1 more visible.*




■ [VIEWS]

*Select* `Auto Scale` {{OK}}

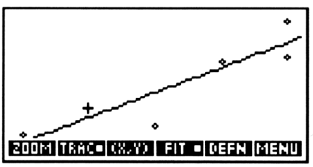
*(If* {{FIT■}} *is on, the regression line also appears.)*




To find the regression curve (a curve to fit the data points) and regression values, set {{FIT■}} on, if it is not already.

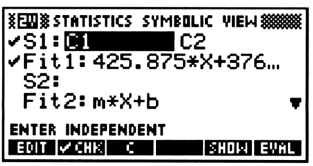
{{MENU}} {{FIT}}

*This draws the regression line for the best linear fit.*



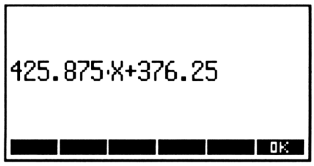

SYMB

*Values for m and b are substituted into the regression expression for the Fit1 field.*



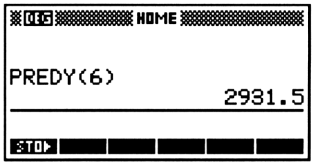
*Highlight Fit1* {{SHOW}}

*Shows the full Fit1 expression. The slope (m) is 425.875. The y-intercept (b) is about 376.25.*




Now find the predicted sales figure if advertising were to go up to 6 minutes. Switch to Home and use PREDY.

{{OK}}
HOME MATH **S** *to highlight* Stat-Two ▶ ▼
*to highlight* PREDY
{{OK}} **6** ENTER




# Entering Statistical Data

You typically enter your data into columns in the Numeric view. Each column represents a variable named C1 through C9 and C0. After entering the data, you must define the data set in the Symbolic view. Data sets are named H1 through H5 for one-variable statistics, or S1 through S5 for two-variable statistics.

**Note**

**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, HOME L1 {{STO▶}} C1 stores the list L1 into the data-column variable C1.

## One-Variable Data

**To enter 1VAR data**

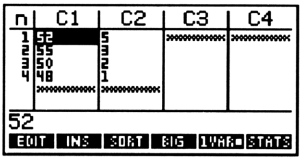
Press [LIB] and select `Statistics`. Press {{START}} or [NUM].

1.

2. Set one-variable {{1VAR■}} statistics. This menu key is a toggle: pressing `1VAR` changes it to `2VAR` and vice-versa.

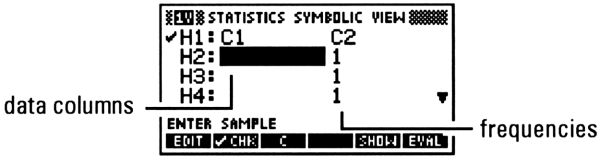
3. Enter each value and press [ENTER]. Put all the values for the same data set in the same column.

   **Entering frequencies:** If a value occurs more than once, you can use another column to record its frequency, rather than entering multiple copies of that value. For instance, C1 could be height values, while C2 could be the number of children of each height. Each cell in C1 would be paired with the adjacent cell in C2 for its frequency.




4. After entering the data values in the Numeric view, press [SYMB] to switch to the Symbolic view.

5. Define the data in a set named H1 through H5.
   - On the left side, specify which column of data to analyze (C1 through C9, C0). (This specification can be an expression, such as `C1+C2`.)
   - On the right side, specify which column (if any) represents the *frequencies* for the values in the left-hand data column. If there is no frequency data column, then the frequency for each data value is 1.




6. You can define up to five data sets (H1 through H5).
7. Checkmark the data sets you want to analyze. Those data sets with checkmarks will be computed and plotted simultaneously. *However, only one histogram can be plotted at a time.*

**To compute 1VAR statistics**

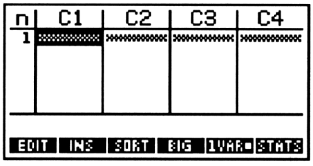
1. Press NUM {{STATS}} to display the results of the computed statistics for the current (checkmarked) data set. These values are defined in the table, "One-Variable Computed Statistics," on page 5-16.
2. Press {{OK}} when done.

**Example: Weighted 1VAR Statistics**

A manufacturing company purchases a certain part four times a year. Enter the purchasing data shown below as one-variable sample data (*price per part*) with frequencies (*number of parts*). Find the *weighted mean*, that is, the mean price weighted for the quantity purchased.

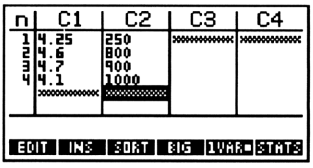
| | | | | |
|---|---|---|---|---|
| Price per part, $ (sample) | 4.25 | 4.60 | 4.70 | 4.10 |
| Number of parts (frequency) | 250 | 800 | 900 | 1000 |

LIB *Select* Statistics
{{START}}
■ [CLEAR] ▶ ■ [CLEAR]
◀ *to clear two data columns, if necessary*

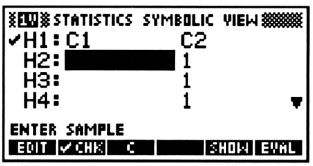



Make sure that {{1VAR■}} is on for one-variable statistics. If it isn't press {{2VAR■}}.

4.25 ENTER 4.6 ENTER 4.7 ENTER 4.1 ENTER
▶ *to move to next column*
250 ENTER 800 ENTER 900 ENTER 1000 ENTER

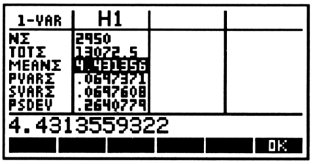



SYMB
{{C}} 1 ENTER {{C}} 2 ENTER



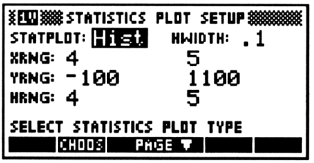

This defines data set H1 with sample data in C1 and frequency data in C2. If H1 is not already checked, press {{√CHK}}.

NUM {{STATS}}
*Displays computed statistics. You can scroll down to see other values, such as the mean.*




The weighted mean price is $4.43 per part.

{{OK}}
■ [SETUP-PLOT]
*Set these X, Y, and H ranges and HWIDTH.*



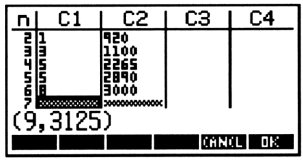
PLOT

*The bar includes 4.10 and has a frequency of 1000.*


## Two-Variable Data

**To enter 2VAR data**

1. Press LIB and select `Statistics`. Press {{`START`}} or NUM.
2. Set two-variable {{`2VAR`■}} statistics. This menu key is a toggle: pressing `1VAR` changes it to `2VAR` and vice-versa.
3. Enter each value and press ENTER. Enter the values for one variable in one column, then move to a second column to enter the values for the second variable.

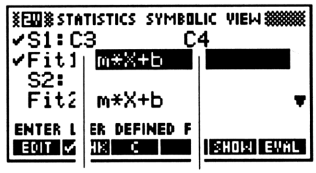



**Entering ordered pairs:** There is an alternative for entering two-variable data. Instead of filling one column and then the other, you enter both variables at once as an ordered pair. Enter the data pair as $(x,y)$ ENTER. This automatically puts $x$ in the current column and $y$ in the column to its right.

4. After entering the data values in the Numeric view, press SYMB to switch to the Symbolic view.

5. Define the data in a set named S1 through S5.

   - In the left-hand column, specify which column of data (C1 through C9, C0) contains the *independent* (*x*) variable data. (This specification can be an expression, such as `C1+C2`.)

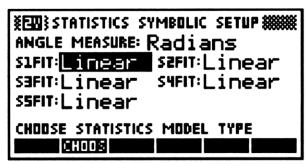



independent (*x*) data

dependent (*y*) data

   - In the right-hand column, specify which column of data holds the *dependent* (*y*) variable data.

4. Select the regression model you would like to use for each data set. The models are labeled S1FIT through S5FIT, corresponding to S1 through S5. Choose the fit in Symbolic Setup view (■ **[SETUP-SYMB]**). If you don't make a selection, the default is a linear fit. (See "Defining a Regression Model," below.)




5. You can define up to five data sets (S1 through S5).

6. Checkmark the data sets you want to analyze. Those data sets with checkmarks will be computed and plotted simultaneously.

**Numeric View Keys**

| Key | Meaning |
|---|---|
| {{EDIT}} | Copies the highlighted item into the edit line. |
| {{INS}} | Inserts a zero value above the highlighted cell. |
| {{SORT}} | Sorts the specified *independent* data column in ascending or descending order, and sorts a specified dependent (or frequency) data column along with it. |
| {{BIG}} | Switches between larger and smaller type sizes. |
| {{1VAR■}}<br>{{2VAR■}} | A toggle switch to set one-variable or two-variable statistics. This setting affects the statistical calculations and plots. The label and ■ indicate which setting is current. |
| {{STATS}} | Computes descriptive statistics for the statistical data specified in Symbolic view. |
| DEL | Deletes the currently highlighted value. |
| ■ [CLEAR] | Clears the current column *or* all columns of data.. |
| ■ *cursor key* | Moves to the first or last row or column. |

**Symbolic View Keys**

| Key | Meaning |
|---|---|
| {{EDIT}} | Copies the column variable (or variable expression) to the edit line for editing. Press {{OK}} when done. |
| {{✓CHK}} | Checks/unchecks the current data set. Only the checkmarked data set(s) are computed and plotted. |
| {{C}} or {{X}} | Typing aid for the column variables (C) or for the Fit expressions (X). |
| {{SHOW}} | Displays the current variable expression in standard mathematical form. Press {{OK}} when done. |
| {{EVAL}} | Evaluates the variables in the highlighted column (C1, etc.) expression. |
| VAR | Menu for entering variable names or contents of variables. |
| MATH | Menu for entering math operations. |
| ■ [CHARS] | Displays special characters. To type one, place the cursor on it and press {{OK}}. |
| DEL | Deletes the highlighted variable *or* the current character in the edit line. |
| ■ [CLEAR] | Resets default specifications for the data sets *or* clears the edit line (if it was active). |

## Managing Statistical Data

**Angle Setting** You can ignore the angle measurement mode *unless* your Fit definition (in Symbolic view) involves a trigonometric function.Then you should specify in the Symbolic Setup view whether the trigonometric units are assumed to be in degrees, radians, or grads.

**Saving Data** *Your data are automatically saved.* When you are done entering data values, you can press a key for another Statistics view (like SYMB), or you can switch to another aplet or Home.

**To edit a data set**

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

**To delete data**

- To delete a single data item, highlight it and press [DEL].
- To delete a column of data, highlight an entry in that column and press ■ [CLEAR]. Select the column name.
- To delete all columns of data, press ■ [CLEAR] in Numeric view. Select `All columns`.

**To 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.

**To sort data values**

1. In Numeric view, put the highlight in the column you want to sort, then press {{SORT}}.
2. Choose "Ascending" or "Descending" order.
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}}.

# Analyzing the Data

First enter your data and define which columns of data make up your data set, then compute their statistical values.

You compute descriptive statistics by pressing the {{STATS}} key in the Numeric view. *For two-variable (2VAR) statistics, you must first define the regression model.*

## Defining a Regression Model (2VAR)

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

There are three ways to select a regression model:

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

**To choose the Fit**

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

**Fit Models**

| Regression Fit | Meaning |
|---|---|
| Linear | (Default.) Fits the data to a straight line, $y = mx+b$. Uses a least-squares fit.<br>`m*X+b` |
| Logarithmic | Fits to a logarithmic curve, $y = m \ln x + b$.<br>`m*LN(X)+b` |
| Exponential | Fits to an exponential curve, $y = be^{mx}$.<br>`EXP(m*X)*b` |
| Power | Fits to a power curve, $y = bx^m$.<br>`X^m*b` |
| Quadratic | Fits to a quadratic curve, $y = ax^2+bx+c$. Needs at least three points.<br>`a*X^2+b*X+c` |
| Cubic | Fits to a cubic curve, $y = ax^3+bx^2+cx+d$. Needs at least four points.<br>`a*X^3+b*X^2+c*X+d` |
| Logistic | Fits to a logistic curve, $y = \frac{L}{1+ae^{(-bx)}}$,<br>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.<br>`L/(1+a*EXP(-b*X))` |
| User Defined | Define your own expression (in Symbolic view.) |

**To define your own fit**

1. In Numeric view, make sure 2VAR is set ({{2VAR■}}).
2. Display the Symbolic view. Highlight the Fit expression (Fit1, etc.) for the desired data set. Type in an expression and press ENTER. The independent variable must be X. Example: 1.5*COS(X)+0.3*SIN(X).

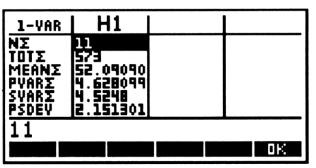
This automatically changes the Fit type (S1FIT, etc.) in the Symbolic Setup to "User Defined."

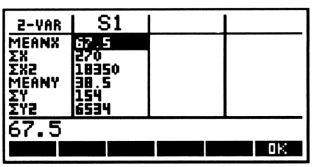
## Computing Statistics (1VAR and 2VAR)

After entering your data values (Numeric view) and defining the data set(s) (Symbolic view), you can compute statistics for the checkmarked data set(s).

**To compute statistics**

1. Press NUM to open the Numeric view. Verify that the appropriate {{1VAR■}} or {{2VAR■}} menu label is on.
2. Press SYMB to open the Symbolic view. Verify that the data set (H or S variable) is defined and that the data set(s) you want to analyze are checkmarked. Press {{√CHK}} to check or uncheck data sets.
3. Press {{STATS}}. You will see a list of computed statistics corresponding to the data set(s) and statistics type (1VAR or 2VAR) you specified. Each column of values is computed from a separate, checkmarked data set (H or S variable).




4. When done, press {{OK}} to return to the Numeric view.

The computed statistics are defined in the following tables. Their values are also stored in variables of the same names. You can access a variable by entering its name in Home, or by recalling it from the VAR menu (press {{APLET}}, highlight Stat-One or Stat-Two, then select the name of the variable). If using the VAR menu in Home, the Statistics aplet must be the current (last used) aplet.

## One-Variable Computed Statistics

| | |
|---|---|
| N$\Sigma$ | Number of data points. |
| TOT$\Sigma$ | Sum of data values (with their frequencies). |
| 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 ordinals to left of median. |
| MEDIAN | Median value of data set. |
| Q3 | Third quartile: median of ordinals to right of median. |
| MAX$\Sigma$ | Maximum data value in data set. |

## Two-Variable Computed Statistics

| | |
|---|---|
| MEANX | Mean of *x*- (independent) values. |
| ΣX | Sum of *x*-values. |
| ΣX2 | Sum of $x^2$-values. |
| MEANY | Mean of *y*- (dependent) values. |
| ΣY | Sum of *y*-values. |
| ΣY2 | Sum of $y^2$-values. |
| ΣXY | Sum of each $x*y$. |
| CORR | Correlation coefficient of the independent and dependent data columns *for a linear fit only* (regardless of the Fit chosen). Returns a value from 0 to 1, where 1 is the best fit. |
| COV | Sample covariance of independent and dependent data columns. |

# Plotting

You can plot:

- Histograms (1VAR).
- Box-and-whisker plots (1VAR).
- Scatter plots of data (2VAR). Pressing {{FIT}} draws a curve to fit the data points according to the current Fit model and calculates regression coefficients.

Once you have entered your data (Numeric view), defined your data set (Symbolic view), and defined your Fit model for two-variable statistics (Symbolic Setup), you can plot your data. You can select up to five Scatter or Box-and-Whisker plots at a time. You can plot only one Histogram at a time.

**To plot statistical data**

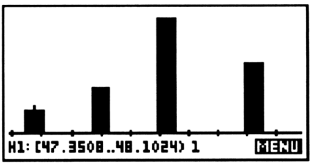
1. In Symbolic view ([SYMB]), select (checkmark) the data sets you want to plot.
2. For one-variable data ({{1VAR■}}), select the plot type in Plot Setup (■ **[SETUP-PLOT]**). Highlight `STATPLOT`, press {{CHOOS}}, select either `Histogram` or `BoxWhisker`, and press {{OK}}.
3. For any plot, but especially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

**Hint**

**Using Autoscaling is often the best way to plot, as it automatically adjusts the plotting scale to the relevant range.**

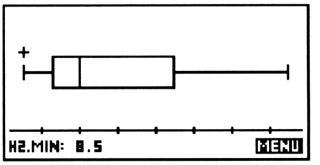
# Plot Types

## Histogram



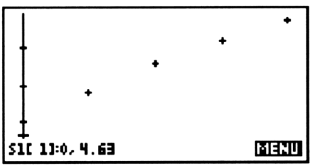

**One-variable statistics**. The numbers below the plot mean that the current bar (where the cursor is) starts at 47.3598 and ends at 48.1024 (not including 48.1024), and the frequency for this column is 1.

## Box and Whisker Plot




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

## Scatter Plot



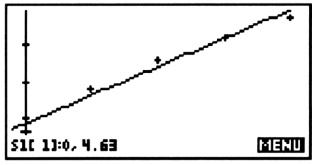

**Two-variable statistics**. The numbers below the plot indicate that the cursor is at the first data point for S1, at (0, 4.63). Plot Setup controls the plotting symbols.

## Fitting a Curve to 2VAR Data

In the Plot view, press {{FIT}} to turn on {{FIT■}}. This calculates a curve to fit the checked two-variable data set(s).

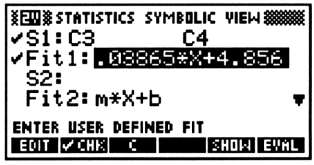
PLOT {{MENU}} {{FIT}}

*(assuming 2VAR is set and two data sets are defined and checked in Numeric and Symbolic views)*




SYMB

The expression in Fit1 shows that the slope=0.03865 and the *y*-intercept=4.856.




## Regression Coefficients

As shown above, the {{FIT■}} mode (in Plot view) calculates and draws a curve to fit the data points using the given regression model. It also substitutes calculated values for the regression coefficient variables in the Fit expression.

**CORR** CORR, the *correlation coefficient*, is a measure of fit to a *linear* curve only. Regardless of the Fit model you have chosen, CORR relates to the linear model.

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

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

## Plot Settings

The Plot Setup view (■ [SETUP-PLOT]) sets most of the same plotting parameters as it does for the other built-in aplets. See "Setting Up the Plot" in chapter 3. Settings unique to the Statistics aplet are:

**Plot Type (1VAR)** STATPLOT specifies either a histogram or a box-and-whisker plot for one-variable statistics (when {{1VAR■}} is set).Use {{CHOOS}} to change the highlighted setting

**Histogram Width** HWIDTH specifies the width of a histogram bar (a 1VAR plot).This determines how many bars will fit in the display, as well as how the data are distributed (how many values each bar represents).

**Histogram Range** HRNG specifies the range of values for a set of histogram bars (a 1VAR plot). The range runs from the left edge of the leftmost bar to the right edge of the rightmost bar.

**Plotting Mark (2VAR)** S1MARK through S5MARK specify one of five symbols to use to plot each data set. Use {{CHOOS}} to change the highlighted setting.

## Trouble-shooting

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

- Data values entered in columns of C variables (Numeric view).
- The correct {{1VAR■}} or {{2VAR■}} menu label on (Numeric view).
- The correct Fit (regression model), if the data are two-variable ({{2VAR■}}). You can change the Fit (as S1FIT through S5FIT) in Symbolic Setup.
- A data set defined as specific data columns (Symbolic view).
- *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).

# Exploring the Plot

The Plot view has menu keys for zooming, tracing, and coordinate display. There are scaling options under ■ [VIEWS]. These features are described in chapter 3 under "Plotting and Analyzing Equations".

**PLOT View Keys**

| Key | Meaning |
|---|---|
| ■ [CLEAR] | Erases the plot. |
| ■ [VIEWS] | Offers additional pre-defined views for splitting the screen, overlaying plots, and autoscaling the axes. |
| ■ ◀<br>■ ▶ | Moves cursor to *far left* or *far right.* |
| {{ZOOM}} | Displays ZOOM menu: Center, Box, In, Out, X or Y In/Out, Square, and Set Factors. |
| {{TRACE}} | Turns Trace mode on/off. The ■ appears when Trace mode is on ({{TRAC■}}). |
| {{(X,Y)}} | Displays the cursor's coordinate position. Press {{MENU}} to restore the menu. |
| {{FIT}} | Turns Fit mode on/off. Turning {{FIT■}} on draws a line to fit the data points according to the given regression model, and calculates regression values, which are substituted for the Fit expressions (FIT1 through F5) in Symbolic view. |
| {{DEFN}} | Temporarily displays the current (*defining*) expression. |
| {{MENU}} | Turns menu-key labels on and off. When the labels are off, any menu key turns them back on. |

## Calculating Predicted Values

The functions PREDX and PREDY will 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.

**To find predicted values**

1. In Plot view, calculate the Fit (regression curve) for the data set:
   - In Symbolic view, your data set (S variable) must be defined and checkmarked. In Symbolic Setup, the fit type must be set.
   - In Plot view, press {{FIT}} to turn on {{FIT■}} and calculate the regression curve. (If {{FIT■}} is already on, press it twice to make it the current regression equation.)
2. In Home, enter PREDX(*y-value*) ENTER to find the predicted (estimated) value for the independent variable given a hypothetical dependent value.
   - Enter PREDY(*x-value*) to find the predicted value of the dependent variable given a hypothetical independent variable.
   - You can type PREDX and PREDY using the Alpha shift, or you can copy these function names from the MATH menu under the Stat-Two category.

# 6

# Using Matrices

You can do 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, such as `[[1,2,3],[4,5,6]]` for

$$\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \end{bmatrix}$$

(If the Decimal Mark in MODES is set to Comma, then the separators are periods.)

**Vectors**

Vectors are one-dimensional arrays. They are composed of just one row or one column. In this calculator, a vector is represented with single brackets; for example, `[1,2,3]`.

**Matrices**

Matrices are two-dimensional arrays. They are composed of more than one row and more than one column. A true, two-dimensional matrix always is represented with nested brackets; for example, `[[1,2,3],[4,5,6]]`.

**Matrix Variables**

There are ten matrix variables available, named M1 through M9 and M0. You can use them in calculations or manipulations in Home or in a program. You can fetch the matrix names from the VAR menu, or just type their names from the keyboard.

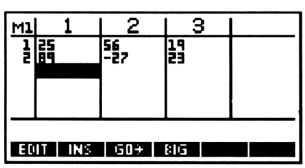
## Creating and Storing Matrices

You can create, edit, delete, send, and receive named matrices in the Matrix catalog (■ **[MATRIX]**).

You can also create and store matrices—named or unnnamed—in Home.

**Creating a Matrix in Matrix Catalog**

1. Press ■ [MATRIX].
2. Highlight the matrix variable name you want to use and press {{NEW}}. (The dimensions will change automatically after the matrix is defined.)
3. Select the type of matrix.
   - **For a vector (one-dimensional array),** select `Real Vector` or `Complex Vector`. Certain operations do not recognize a one-dimensional matrix as a vector, so this selection is important.
   - **For a matrix (two-dimensional array),** select `Real Matrix` or `Complex Matrix`.
4. For each element in the matrix, type a number or an expression, and press [ENTER]. (The expression may not contain symbolic variable names.)
   - **For complex numbers,** enter each number in complex form; that is, `(a,b)`, where *a* is the real part and *b* is the imaginary part. You must include the parentheses and the comma.
5. Use the cursor keys to move to a different row or column. You can change the direction that the highlight automatically advances by pressing {{GO}} to display {{GO→}} or {{GO ↓ }}. For no automatic movement, display {{GO}}.
6. When done, press ■ [MATRIX] to see the Matrix catalog, or press [HOME] to return to the Home screen for calculations, or start any other activity (such as an aplet) you want. *The matrix entries are automatically stored.*





The Matrix Catalog automatically lists the correct matrix dimensions. A matrix is listed with two dimensions, even if it is `3×1`. A vector is listed with one dimension, such as `3`.

**To edit a matrix**

In the Matrix catalog, highlight the matrix name you want and press {{EDIT}} instead of {{NEW}}.

**Matrix Catalog Keys**

| Key | Meaning |
|---|---|
| {{EDIT}} | Opens the highlighted matrix for editing. |
| {{NEW}} | Prompts for a matrix type, then opens an empty matrix with the highlighted name. |
| {{SEND}} | Transmits the highlighted matrix to another HP 38G or a disk drive. Works like sending an aplet (chapter 1). |
| {{RECV}} | Receives a transmitted matrix from another HP 38G or a disk drive. Works like receiving an aplet (chapter 1). |
| DEL | Clears the highlighted matrix. |
| ■ [CLEAR] | Clears all matrices. |
| ■ ▼ or ▲ | Moves to the end or the beginning of the catalog. |

**Matrix Editing Keys**

| Key | Meaning |
|---|---|
| {{EDIT}} | Copies the highlighted element into the edit line. |
| {{INS}} | Inserts a row of zeros above, or a column of zeros to the left, of the highlighted cell. (You choose row or column.) |
| {{GO}} | A three-way toggle for cursor advancement in the Matrix editor. {{GO→}} advances to the right, {{GO ↓ }} advances downward, and {{GO}} does not advance at all. |
| {{BIG}} | Switches between larger and smaller type sizes. |
| DEL | Deletes the row or column (you choose) currently highlighted. |
| ■ [CLEAR] | Clears all elements from the matrix. |
| ■ *cursor key* | Moves to the first or last row or column. |

**To display a matrix**

- In the Matrix catalog (■ [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 delete a matrix**

In the Matrix catalog (■ [MATRIX]), highlight the matrix to delete and press DEL. The name remains. The matrix is redimensioned to 1×1 with a zero element.

**To delete all matrices**

In the Matrix catalog (■ [MATRIX]), press ■ [CLEAR].

**To delete a row or column**

Pressing DEL clears one row or column in a matrix. (You are prompted to choose.)

**To transmit a matrix**

You can send and receive matrices to/from other calculators just as you can send and receive aplets, programs, lists, and notes.

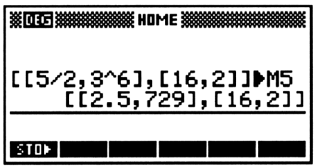
After aligning the calculators' infrared ports, open the Matrix catalogs on both calculators. Highlight the matrix to send, then press {{SEND}} on the sending calculator and {{RECV}} on the receiving calculator. See "Sending and Receiving Aplets," in chapter 1.

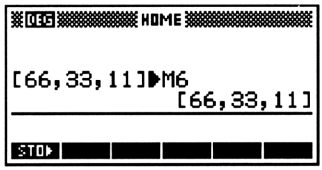
**Creating a Matrix in Home**

1. Enter the matrix in the edit line. Start and end the matrix *and each row* with brackets (the shifted [5] and [6] keys).
2. Separate each element *and each row* with a comma. Example: `[[1,2],[3,4]]`. (Note: if the Decimal Mark in MODES is set to Comma, use *periods* as separators.)
3. An array of just one dimension (a vector) needs only one set of brackets. Example: `[1,2,3]`.
4. Press [ENTER] to enter and display the matrix.

Immediately after typing in the matrix, you can store it in a variable by typing {{STO▶}} *matrixname* [ENTER]. The matrix variable names are M1 through M9, and M0.

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, type
`728` {{STO▶}} `M5(1,2)` [ENTER].

# Matrix Arithmetic

You can use the arithmetic functions (+, −, ×, /) with matrix arguments. Multiplication and division have different meanings depending on whether one of the arguments is a scalar or not.

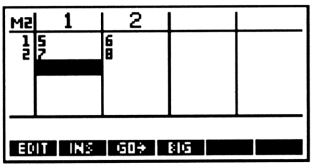
**Adding and Subtracting**

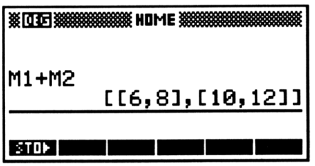
For addition and subtraction, the dimensions of the matrices must be the same. You can enter the matrices themselves or enter the names of stored matrix variables. The matrices can be real or complex.

For the next four examples, store [[1,2],[3,4]] into M1 and [[5,6],[7,8]] into M2.

■ [MATRIX] {{NEW}} {{OK}}
1 ENTER 2 ENTER ▼ 3
ENTER 4 ENTER
■ [MATRIX] ▼ {{NEW}}
{{OK}} 5 ENTER 6 ▼
ENTER 7 ENTER 8 ENTER

HOME A...Z M 1 +
A...Z M 2 ENTER



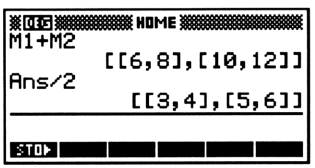




**Multiplying and Dividing by a Scalar**

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.

/ 2 ENTER

*(This divides the previous matrix sum by 2.)*

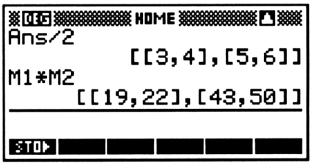


**Multiplying Two Matrices**

Multiplication of two matrices is *not* commutative. The number of columns of the first matrix must equal the number of rows of the second matrix.

Assume that M1 still contains [[1,2],[3,4]] and M2 still contains [[5,6],[7,8]].

A...Z M 1 * A...Z M 2 ENTER




The result has the same number of rows as the first matrix and the same number of columns as the second matrix.

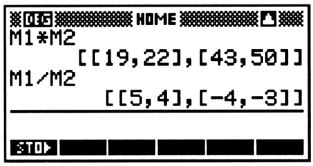
**To multiply a matrix by a vector**, enter the matrix first, then the vector. The number of elements in the vector must equal the number of columns in the matrix.

**Dividing 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.

Assume that M1 still contains [[1,2],[3,4]] and M2 still contains [[5,6],[7,8]].

A...Z M 1 / A...Z M 2 ENTER




The result is $M2^{-1} * M1$.

**Inverting a Matrix**

You can invert a *square matrix* in Home by typing the matrix (or its variable name) and pressing ■ [$x^{-1}$] ENTER. (Or you can enter `INVERSE(`*matrixname*`)` in Home.)

**Negating Each Element**

You can change the sign of each element in a matrix by pressing (-x) before the matrix name.

## Solving Systems of Linear Equations

Remember that a system of equations can be represented by a matrix equation :

| Equation Form | Matrix Form |
|---|---|
| $ax + by + cz = k_1$<br>$dx + ey + fz = k_2$<br>$gx + hy + iz = k_3$ | $\begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} k_1 \\ k_2 \\ k_3 \end{bmatrix}$ |

Using the matrix form, the solution is the vector of variables, as shown below.

| Constants Vector | Coefficients Matrix | Variables Vector *(result)* |
|---|---|---|
| $[k_1, k_2, k_3]$ | $[[a, b, c][d, e, f][g, h, i]]$ | $[x, y, z]$ |

The coefficient matrix must be *square* (the number of coefficients per equation equals the number of equations).

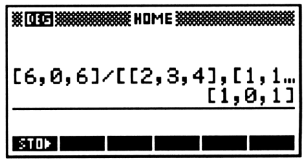
**To solve linear equations**

1. In Home, enter the constants vector or the name of a stored constants vector (M1...M9, M0). (*This must be a vector,* which has a single set of brackets, *not a matrix,* which has multiple sets of brackets.)
2. Press [/].
3. Enter the coefficients matrix or the name of a stored *square* coefficients matrix (M1...M9, M0).
4. Press [ENTER]. The resulting variables vector is displayed.

**Example**

Find all $[x, y, z]$ satisfying
$2x + 3y + 4z = 6$
$x + y - z = 0$
$4x - y + 2z = 6$

The constants vector is [6,0,6]. The coefficients matrix is [[2,3,4],[1,1,−1],[4, −1,2]]. The solution for this system of linear equations (that is, constants vector divided by coefficients matrix) is [1,0,1].




To see the full input expression, first copy it to the edit line (press ▲ ▲ {{COPY}}), then press ▶ to scroll through the expression.

# Matrix Functions

There are two categories of matrix operations: *functions* and *commands*. The matrix functions are given in the following table. The matrix commands are for programming; they appear in chapter 8, Programming.

**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. 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])`.
- If Decimal Mark in MODES is set to Comma, use periods to separate arguments. For example, `CROSS(`*vector1*`.`*vector2*`)`.

**Commands**

Commands are limited to programs. Matrix commands are listed in the MATH menu ([MATH] {{CMDS}}), category Matrix.

**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 arguments *matrix* and *matrixname* can refer to either a vector or a matrix.

**Output**

Functions return results to the display (and to the variable *Ans*).

Results can be displayed with single brackets (for a vector) or double brackets (for 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.<br>`COLNORM(`*matrix*`)` |
| **COND** | Condition Number. Finds the 1-norm (column norm) of a square *matrix*.<br>`COND(`*matrix*`)` |
| **CROSS** | Cross Product of *vector1* × *vector2*.<br>`CROSS(`*vector1*`,`*vector2*`)` |
| **DET** | Determinant of a square *matrix*.<br>`DET(`*matrix*`)` |
| **DOT** | Dot Product of two arrays, *matrix1* · *matrix2*.<br>`DOT(`*matrix1*`,` *matrix2*`)` |
| **EIGENVAL** | Displays the eigenvalues in vector form for *matrix*.<br>`EIGENVAL(`*matrix*`)` |
| **EIGENVV** | Eigenvectors and Eigenvalues for a square *matrix*. Displays a list of two arrays. The first contains the eigenvectors and the second contains the eigenvalues.<br>`EIGENVV(`*matrix*`)` |
| **IDENMAT** | Identity matrix. Creates a square matrix of dimension *size*×*size* whose diagonal elements equal 1 and off-diagonal elements equal zero.<br>`IDENMAT(`*size*`)` |
| **INVERSE** | Inverts a square matrix (real or complex).<br>`INVERSE(`*matrixname*`)` |

## Matrix Functions, continued

| | |
|---|---|
| **LQ** | LQ Factorization. Factors *m*×*n matrix* into three matrices: { [ [ *m*×*n lowertrapezoidal* ] ] , [ [ *n*×*n orthogonal* ] ] , [ [ *m*×*m permutation* ] ] }.<br>`LQ(`*matrix*`)` |
| **LSQ** | Least Squares. Displays the minimum norm least squares matrix (or vector).<br>`LSQ(`*matrix1* `,` *matrix2*`)` |
| **LU** | LU Decomposition. Factors a square *matrix* into three matrices: { [ [*lowertriangular*] ] , [ [*uppertriangular*] ] , [ [*permutation*] ] } The *uppertriangular* has ones on its diagonal.<br>`LU(`*matrix*`)` |
| **MAKEMAT** | Make Matrix. Creates a matrix of dimension *rows* × *columns*, using *expression* to calculate each element. If *expression* contains the variables I and J, then the calculation for each element substitutes the current row number for I and the current column number for J.<br>`MAKEMAT(`*expression* `,` *rows* `,` *columns*`)`<br>Example: `MAKEMAT(0,3,3)` returns a 3×3 zero matrix, [[0,0,0],[0,0,0],[0,0,0]]. |
| **QR** | QR Factorization. Factors an *m*×*n matrix* into three matrices: { [ [*m*×*m orthogonal*] ] , [ [*m*×*n uppertrapezoidal*] ] , [ [*n*×*n permutation*] ] }.<br>`QR(`*matrix*`)` |
| **RANK** | Rank (an integer) of a rectangular *matrix*.<br>`RANK(`*matrix*`)` |
| **ROWNORM** | Row Norm. Finds the maximum value (over all rows) of the sums of the absolute values of all elements in a row.<br>`ROWNORM(`*matrix*`)` |
| **RREF** | Reduced Row-Echelon. Changes a rectangular *matrix* to its reduced row-echelon form.<br>`RREF(`*matrix*`)` |

## Matrix Functions, continued

| | |
|---|---|
| **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*] ] }.<br>SCHUR (*matrix*) |
| **SIZE** | Dimensions of *matrix*. Returned as a list: {rows,columns}.<br>SIZE (*matrix*) |
| **SPECNORM** | Spectral Norm of the specified array.<br>SPECNORM (*matrix*) |
| **SPECRAD** | Spectral Radius of a square *matrix*.<br>SPECRAD (*matrix*) |
| **SVD** | Singular Value Decomposition. Factors an *m*×*n matrix* into two matrices and a vector : { [ [*m*×*m square orthogonal*] ] , [ [*n*×*n square orthogonal*] ] , [*real*] }.<br>SVD (*matrix*) |
| **SVL** | Singular Values. Returns a vector containing the singular values of *matrix*.<br>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.)<br>TRACE (*matrix*) |
| **TRN** | Transposes *matrix*. For a complex matrix, TRN finds the conjugate transpose.<br>TRN (*matrix*) |

## Examples

**Filling Matrices**

You can create and fill a matrix with zeros for the diagonal elements and ones for the off-diagonal elements using the MAKEMAT (*make matrix*) function. For example, entering `MAKEMAT(I≠J,4,4)` creates a 4×4 matrix with ones for all elements except zeros on the diagonal. The logical operator ≠ returns 0 when I (the row number) and J (the column number) are equal, and returns 1 when they are not equal.

**Identity Matrix**

You can create an identity matrix with the IDENMAT function. For example, `IDENMAT(2)` creates the 2×2 identity matrix [[1,0],[0,1]].

**Redimension a Matrix**

Suppose the variable M0 is a 2×2 matrix containing [[3,4],[5,6]]. The programming command `REDIM M0;{2,1}` would redimension it to a matrix of 2 rows×1 column, [[3],[4]]. The command `REDIM M0;{4}` would redimension it to the column vector [3,4,5,6]. To see the redimensioned matrix, either recall the matrix to the edit line ([A...Z]**M 0** [ENTER]), or use the Matrix editor (■ **[MATRIX]**).

**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]]`.

# 7

# Using Lists

You can do list operations in Home (and in programs). The elements of a list appear in braces and are separated by commas, such as `{A,B,C}` or `{1,2,3}`. (If the Decimal Mark in MODES is set to Comma, then the separators are periods.)

**List Variables**

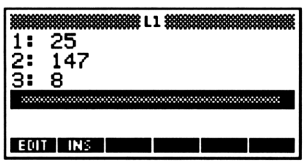
There are ten list variables available, named L1 through L9 and L0. You can use them in calculations or expressions in Home or in a program. You can fetch the list names from the VAR menu, or just type their names from the keyboard.

## Creating and Storing Lists

You can create, edit, delete, send, and receive named lists in the List catalog (■ [LIST]). You can also create and store lists—named or unnnamed—in Home.

**Creating a List in List Catalog**

1. Press ■ [LIST].
2. Highlight the list name you want to use (L1, etc.) and press {{EDIT}}.
3. For each item, enter the value and press [ENTER]. This value can be a real or complex number (or an expression).
4. When done, press ■ [LIST] to see the List catalog, or press [HOME] to return to the Home screen for calculations. Or start any other activity (such as an aplet) you want.




**List Catalog Keys**

| Key | Meaning |
|---|---|
| {{EDIT}} | Opens the highlighted list for editing. |
| {{SEND}} | Transmits the highlighted list to another HP 38G or a disk drive. Works like sending an aplet (chapter 1). |
| {{RECV}} | Receives a transmitted list from another HP 38G or a disk drive. Works like receiving an aplet (chapter 1). |
| DEL | Clears the highlighted list. |
| ■ [CLEAR] | Clears all lists. |
| ■ ▼ or ▲ | Moves to the end or the beginning of the catalog. |

**List Editing Keys**

| Key | Meaning |
|---|---|
| {{EDIT}} | Copies the highlighted list item into the edit line. |
| {{INS}} | Inserts the value you type as the item before the highlighted item. |
| DEL | Deletes the highlighted item from the list. |
| ■ [CLEAR] | Clears all elements from the list. |
| ■ ▼ or ▲ | Moves to the end or the beginning of the list. |

**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 delete a list** In the List catalog (■ [LIST]), highlight the list name and press DEL. The name remains.

**To delete all lists** In the List catalog (■ [LIST]), press ■ [CLEAR].

**To transmit a list**

You can send and receive lists to/from other calculators just as you can send and receive aplets, programs, matrices, and notes.

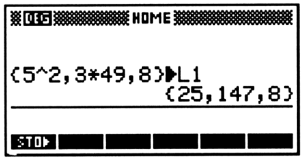
After aligning the calculators' infrared ports, open the List catalogs on both calculators. Highlight the list to send, then press {{SEND}} on the sending calculator and {{RECV}} on the receiving calculator. See "Sending and Receiving Aplets," in chapter 1.

**Creating a List in Home**

1. Enter the list in the edit line. Start and end the list with braces (the shifted [8] and [9] keys) and separate each element with a comma.
2. Press [ENTER] to evaluate and display a list.

Immediately after typing in the list, you can store it in a variable by typing {{STO▶}} *listname* [ENTER]. The list variable names are L1 through L9 and L0.

This example stores the list {25,147,8} in L1. (You can omit the final brace when entering a list.)




**To store one element**

In Home, enter *value* {{STO▶}} *listname*(*element*). For example, to change the second element of L1 to 148, type `148` {{STO▶}} `L1(2)` [ENTER].

# List Functions

Following is a table of list functions. 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] [A...Z] L. This displays the List category. Highlight the function on the right-hand side and press {{OK}}.

**Function 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 data inside braces. For example, `REVERSE({1,2,3})`.
- If Decimal Mark in MODES is set to Comma, use periods to separate arguments. For example, `CONCAT(L1.L2)`.

**List Functions**

| | |
|---|---|
| ***any real-number operator*** | Operators like +, −, ∗, /, and $\sqrt{\ }$ can take lists as arguments. If there are two arguments and both are lists, then the lists must have the same length, since the calculation pairs up the elements. If there are two arguments and one is a real number, then the calculation pairs the number with each element of the list.<br>*list1* + *list2*<br>*value* + *list*<br>*list* + *value*<br>Example: $\sqrt{\ }${4,9,16} returns {2,3,4}. |
| **CONCAT** | Concatenates two lists into a new list.<br>CONCAT(*list1*, *list2*)<br>Example: CONCAT({1,2,3},{4}) returns {1,2,3,4}. |

## List Operations, continued

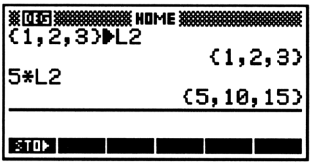
| | |
|---|---|
| **ΔLIST** | Creates a new list composed of the differences between the sequential elements in *list1*. The new list has one fewer elements than *list1*. The first differences for $\{x_1\ x_2 \ldots x_n\}$ are $\{x_2-x_1 \ldots x_n-x_{n-1}\}$.<br>ΔLIST(*list1*) |
| **MAKELIST** | Calculates a sequence of elements for a new list. Evaluates expression with *variable* from *begin* to *end* values, taken at *increment* steps.<br>MAKELIST(*expression*, *variable*, *begin*, *end*, *increment*) |
| **πLIST** | Calculates the product of all elements in list.<br>πLIST(*list*)<br>Example: πLIST({2,3,4}) returns 24. |
| **POS** | The position (a number) of an element within a list. The *element* can be a value, a variable, or an expression.<br>POS(*list, element*) |
| **REVERSE** | Reverses order of elements in list into a new list.<br>REVERSE(*list*) |
| **SIZE** | Number of elements in a list.<br>SIZE(*list*) |
| **ΣLIST** | Calculates the sum of all elements in list.<br>ΣLIST(*list*)<br>Example: ΣLIST({2,3,4}) returns 9. |
| **SORT** | Sorts elements in ascending order.<br>SORT(*list*) |

**Using Lists in Expressions**

You can use a list name or the explicit list in an expression using any of the real-number functions.

Press ENTER to evaluate the expression.

HOME
■ { 1 , 2 , 3 ■ }
{{STO▶}} A...Z L 2 ENTER
5 * A...Z L 2 ENTER




**Generating a Series**

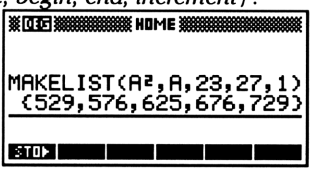
The MAKELIST operation generates a series by automatically producing a list from the repeated evaluation of an expression.

**Example**

In Home, generate a list of squares from 23 to 27 using the expression $A^2$.

Copy MAKELIST from the MATH menu. The syntax is MAKELIST(*expression, variable, begin, end, increment*).

MATH L ▶
*Select* MAKELIST {{OK}}
A...Z A ■ [$x^2$] , A...Z A ,
23 , 27 , 1 )
ENTER




**Finding First Differences**

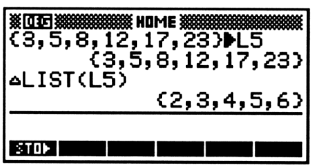
Finding the first differences is a way of finding the rate of change in a series of values. In Home or in a program, the ΔLIST operation finds the first differences.

**Example**

In the List catalog or in Home, store {3,5,8,12,17,23} in L5. In Home, find the first differences for this list.

HOME ■ [{] 3,5,8,12,17,23
■ [}] {{STO▶}} A...Z L 5
ENTER

MATH L ▶
*Select* ΔLIST {{OK}}
A...Z L 5 ENTER



## 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.

Given list data in a list variable (L1, for example), store L1 into a data column variable (C1, for example), and then compute its statistics.

1. In Home, store L1 into C1. You will be able to see the list data in the Numeric view of the Statistics aplet.
2. In the Numeric view of the Statistics aplet, set 1VAR mode (press {{2VAR■}}, if necessary, to display {{1VAR■}}).
3. In the Symbolic view, define H1 (for example) as C1 (sample) and 1 (frequency). Make sure that H1 is checkmarked.
4. In the Numeric view, press {{STATS}}.

   NΣ is the number of elements in L1.
   TOTΣ is the sum of all elements in L1.
   MEANΣ is the mean value of all elements in L1.
   MINΣ is the smallest element in L1.
   MEDIAN is the median value of all elements in L1.
   MAXΣ is the largest element in L1.

# 8

# Programming

This chapter describes how to program using the HP 38G. 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.

## The Contents of a Program

An HP 38G 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 in other programs.

**Example**

```
RUN GETVALUE: RUN CALCULATE: RUN SHOWANSWER
```

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.

# Using the Program Catalog

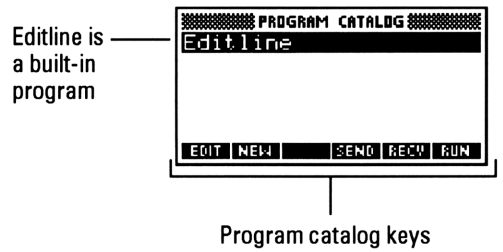
The Program catalog is where you create, edit, delete, send, receive, or run programs. This section describes how to

- Open the Program catalog.
- Enter commands with the Math menu.
- Create a new program.
- Edit a program.
- Send and receive a program.
- Delete a program or its contents.
- Run and debug a program.
- Stop a program.
- Copy a program.

**To open the Program catalog**

- Press ■ [PROGRAM].
  The Program catalog displays a list of program names. If you haven't created any programs, the only name you'll see is Editline.

  Editline contains the last expression that you entered from the edit line in HOME (or the last data you entered in an input form). If you press ENTER from HOME without entering any data, the HP 38G runs to contents of Editline.



Before starting to work with programs, you should take a few minutes to become familiar with the Program catalog keys. You can use any of the following keys (both menu and keyboard), to perform tasks in the Program catalog.

**Program catalog keys**

| Key | Meaning |
|---|---|
| {{EDIT}} | Opens the highlighted program for editing. |
| {{NEW}} | Prompts for a new program name, then opens an empty program. |
| {{SEND}} | Transmits the highlighted program from another HP 38G or from a disk drive. |
| {{RECV}} | Receives the highlighted program to another HP 38G or to a disk drive. |
| {{RUN}} | Runs the highlighted program. |
| ■ ▼ or ▲ | Moves to the end or the beginning of the Program catalog. |
| DEL | Delete the highlighted program. |
| ■ [CLEAR] | Deletes all programs in the Program catalog. |

**To create a new program**

1. Press ■ [PROGRAM] to open the Program catalog.
2. Press {{NEW}}.
   The HP 38G prompts you for a file name.


A program name can contain special characters, such as a space. However, if you use special characters and then run the program by typing it in HOME, you must enclose the program name in double quotes (" "). Don't use the " symbol within your program name.

3. Type your program name, then press {{OK}}.
   When you press {{OK}}, the Program Editor opens.

4. Enter your program. When done, start any other activity.
   Your work is saved automatically.

**To enter commands**

Until you learn the abbreviated spelling for the HP 38G commands, the easiest way to enter commands is to use the Math menu from the Program editor.

1. From the Program editor, press [MATH] {{CMDS}}.
2. On the left, highlight a command category, then press [▶].


4. On the right, highlight a command, then press {{OK}}.


**To save a program**

There is no need to save your program. As you work, your program is *saved automatically* under the program name you specified.

**To edit a program**

1. Press ■ [PROGRAM] to open the Program catalog.
2. Use the arrow keys to highlight the program you want to edit.
3. Press {{EDIT}}.
   The HP 38G 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.

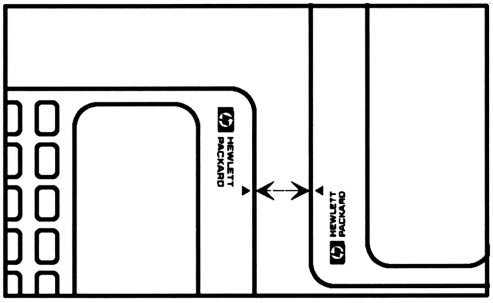
**Editing keys**

| Key | Meaning |
|---|---|
| {{STO▶}} | Stores a number into a named variable. |
| {{SPACE}} | Inserts space into text. |
| {{▲PAGE}} | Displays previous page of the program. |
| {{PAGE▼}} | Displays next page of the program. |
| ▲ ▼ | Moves up or down one line. |
| ▶ ◀ | Moves right or left one space. |
| {{A . . . Z}} | Alpha-lock for letter entry. Press ■ {{A...Z}} to lock lower case. |
| {{BKSP}} | Backspaces cursor and deletes character. |
| DEL | Deletes current character. |
| ENTER | Starts a new line. |
| ■ [CLEAR] | Erases the entire program. |
| VAR<br>MATH | Menus for entering variable names, contents of variables, math functions, program commands, and program constants. |
| ■ [CHARS] | Displays all non-keyboard characters. To type one, highlight it and press {{OK}} or {{ECHO}} to type several characters. |

**To send and receive a program**

You can send and receive programs to and from another HP 38G or disk drive—just as you can send and receive aplets, lists, matrices, and notes.

1. Connect the storage device to the calculator by cable
   *or*
   align the two calculators' infrared ports by matching up the triangle marks on the rims of the calculators. Place the calculators no more than 2 inches (5 cm) apart.




2. **Sending calculator** : Open the Program catalog, highlight the program to send, and press {{SEND}}.
   - You have two options—another HP 38G or a disk drive (or a computer). Highlight your selection and press {{OK}}.
   - If transmitting to a disk drive (aplet disk drive or computer), you have the options of sending to the current (default) directory or to another directory.
3. **Receiving calculator** : Open the Program catalog and press {{RECV}}.
   - You have two options—another HP 38G or a disk drive (or computer). Highlight your selection and press {{OK}}.

   The annunciator line displays ⏩ until transmission is complete.

**To delete a program**

You can delete any program except Editline.

1. Press ■ [PROGRAM] to open the Program catalog.
2. Highlight a program to delete, then press [DEL].

**To delete all programs**

- Press ■ [CLEAR], then press {{YES}}.

**To delete the contents of a program**

1. Press ■ [PROGRAM] to open the Program catalog.
2. Highlight a program , then press {{EDIT}}.
3. Press■ [CLEAR], then press {{YES}}
   The contents of the program are deleted, but the program name remains.

**To run a program**

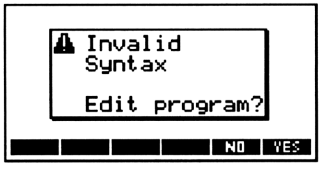
From HOME, type RUN *program_name.*
*or*
From the Program catalog, highlight the program you want to run and press {{RUN}}.

*Regardless of where you start the program, all programs run in HOME.* What you see will differ slightly depending on where you started the program. If you start the program from HOME, the HP 38G displays the contents of Ans (Home variable containing the last result), when the program has finished. If you start the program from Program catalog, the HP 38G returns you the Program catalog when the program ends.

**To debug a program**

If you run a program that contains errors, the program will stop and you'll see an error message.

1. Choose {{YES}} to edit the program.



2. A flashing arrow appears in the program at the point where the error occurred.


The character preceding the arrow contains a syntax error.

3. You can continue to run, then edit the program until you find and correct all errors.

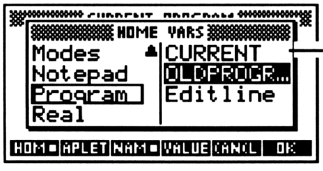
**To stop a program**

You can stop the execution of a program at any time by pressing [CANCEL] (the ON key).

**To 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 ■ [PROGRAM] to open the Program catalog.
2. Press {{NEW}}.
3. Type a new file name, then choose {{OK}}.
   The Program Editor opens with an empty new program.
4. Press VAR to open the Variable menu.
5. Press P to quickly scroll to Program.
6. Press ▶, then highlight the program you want to copy.
7. Press {{VALUE}}, then press {{OK}}.




The HP 38G copies the contents of the highlighted program into the current (open) program.

# Programming Commands

This section describes the commands for programming with the HP 38G. You can enter these commands in your program by typing them or by accessing them from the Math menu.

1. Press ■ **[PROGRAM]** to open the Program catalog.
2. Press {{NEW }} or {{EDIT}} to open the Program editor.


The Program editor is where you enter new programs or edit existing ones.

2. From the Program editor, press [MATH] {{CMDS}}.

The HP 38G displays the Program Commands menu. The left side of the screen shows the *command categories* and the right side of the screen shows the available *commands*.


Program categories

Program commands

## Aplet Commands

These commands control aplets.

**CHECK** Checks (selects) the corresponding function in the current aplet. For example, Check 3 would check F3 if the current aplet is Function. Then a checkmark would appear next to F3 in Symbolic view, F3 would be plotted in Plot view, and evaluated in Numeric view.

```
CHECK n
```

**SELECT** Selects the named aplet and makes it the current aplet.

```
SELECT apletname
```

**SETVIEWS** Takes trios of arguments. Used to define entries in the VIEWS menu for aplets. *Prompt* is the text to display for an entry in the Views menu. *Programname* is the name of a program to run if the entry is selected. The *viewnumber* is the number of a view to start after the program finishes running. The views are numbered as follows:

| | | | |
|---|---|---|---|
| 0. | 0 to go to Home | 9. | Note |
| 1. | Plot | 10. | SketchLibrary |
| 2. | Symbolic | 11. | List Catalog |
| 3. | Numeric | 12. | Matrix Catalog |
| 4. | Plot-Setup | 13. | Notepad Catalog |
| 5. | Symbolic-Setup | 14. | Programs |
| 6. | Numeric-Setup | 15. | Use 15, 16... for Views menu items |
| 7. | Views | | |

```
SETVIEWS prompt;programname;viewnumber;
         prompt;programname;viewnumber:
```

(You can repeat as many trios of arguments as you like.)

**NCHECK** Unchecks (unselects) the corresponding function in the current aplet. For example, Uncheck 3 would uncheck F3 if the current aplet is Function.

```
UNCHECK n
```

## Branch Commands

A programming structure allows a program to control how it should execute depending on given conditions or the values of particular arguments. The HP 38G has two kinds of *control structures*:

- Branch structures.
- Loop structures.

*Branch structures* let a program make a decision based on the result of one or more tests. Here is a summary of the branch structures available on the HP 38G. (Unlike the other programming commands, the control structure commands work in logical groups. Therefore, the commands are described together rather than each independently.)

**IF...THEN... ELSE...END**

Executes a sequence of commands in the *test-clause* only if the *test-clause* evaluates to true. Its syntax is:

```
IF test-clause
THEN true-clause ELSE false-clause 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.

**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*$_1$ is evaluated. If the test is true, *true-clause*$_1$ is executed, and execution skips to END. If *test-clause*$_1$ if false, execution proceeds to *test-clause*$_2$. Execution with the CASE structure continues until a true-clause is executed (or until all the test-clauses evaluate to false).

**IFERR... THEN... ELSE...** Many conditions are automatically recognized by the HP 38G as *error conditions*—and they're automatically treated as errors in programs.

IFERR...THEN...ELSE allows a program to intercept error conditions that otherwise would cause the program to abort. Its syntax is:

```
IFERR trap-clause
 THEN error-clause ELSE normal-clause END
```

**RUN** Runs the named program. If your program name contains special characters, such as a space, and then you must enclose the file name in double quotes (" ").

```
RUN "program name" or RUN programname
```

**STOP** Stops the current program.

```
STOP
```

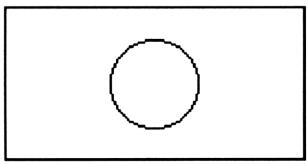
## Drawing Commands

The Drawing commands act on the display. The scale of the display depends on the current aplet's Xmin, Xmax, Ymin, and Ymax values. *The following examples assume the HP 38G default settings with the Function aplet as the current aplet.*

**ARC** Draws an arc with center (*x,y*), *radius*, *start_angle_measurement*, and end_angle_measurement.

```
ARC x;y;radius;start_angle_measurment;
end_angle_measurment
```

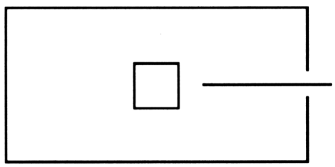
**Example** `ARC 0;0;2;0;360`
Draws circle centered at (0,0) of radius 2.



**BOX** Draws a box with opposite corners (*x1,y1*) and (*x2,y2*).

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

**Example** `BOX -1;-1;1;1`
Draws a box, lower corner at (-1,-1), upper corner at (1,1).



Use the FREEZE command to display the graphic until the user presses a key.

**ERASE** Clears the display.

```
ERASE
```

**FREEZE** Keeps the display from being updated after a program finishes running.

**LINE** Draws a line from (*x1, y1*) to (*x2, y2*).

```
LINE x1;y1;x2;y2
```

**Example** `LINE 0;0;3;3`
Draws a line from (0,0) to (3,3).

**PIXOFF** Turns off the pixel at the specified coordinates (*x,y*).

```
PIXOFF x;y
```

**PIXON** Turns on the pixel at the specified coordinates (*x,y*).

```
PIXON x;y
```

**TLINE** Toggles the pixels along the line from (*x1, y1*) to (*x2, y2*). Any pixel that was turned off, will be turned on; any pixel that was turned on, will be turned off. TLINE can be used to erase a line.

```
TLINE x1;y1;x2;y2
```

**Example** `TLINE 0;0;3;3`
Erases previously drawn 45 degree line from (0,0) to (3,3).

## Graphic Commands

The Graphic commands use the graphics variables G0–G9 as name arguments—or the Page variable from Sketch. Position arguments take the form (x,y). Position coordinates depend on the current aplet's scale which is specified by Xmin, Xmax, Ymin, and Ymax.

**DISPLAY→** Stores the current display in name.

```
DISPLAY→ name
```

**→DISPLAY** Displays graphic from name in the display.

```
→DISPLAY name
```

**→GROB** Creates a graphic from *expression*, using *font_size*, and stores the resulting graphic in *name*. Font sizes are 1, 2, or 3. If the *font_size* argument is 0, the HP 38G creates a graphic display like that created by the SHOW operation.

```
→GROB  name;expression;font_size
```

**GROBNOT** Replaces graphic in *name* with bitwise-inverted graphic from *name*.

```
GROBNOT  name
```

**GROBOR** Using the logical OR, superimposes *graphic* onto *name* starting at the specified coordinate in *position*.

```
GROBOR
name_graphic1;position;name_graphic2
```

**Example** `GROBOR G1;(0,0);G2`

**GROBXOR** Using the logical XOR, superimposes *graphic* onto *name* starting at the specified coordinate in *position*.

```
GROBXOR  name;position; graphic
```

**MAKEGROB** Creates graphic with given width, height, and hexadecimal data, and stores it in *name*.

```
MAKEGROB  name;width height hex-data
```

| | |
|---|---|
| **PLOT→** | Stores the Plot view display as a graphic in *name*.<br><br>`PLOT→ name` |
| **→PLOT** | Puts graph from name into the Plot view display.<br><br>`→PLOT name` |
| **REPLACE** | Replaces portion of graphic in *name* with another *graphic*, starting at position *start* (in form x,y). REPLACE also works for lists and matrices.<br><br>`REPLACE name;(start_x, start_y);graphic` |
| **SUB** | Extracts a portion of a list, matrix, or graphic (specified by *start* and *end*—in form x,y), and stores it in *name*.<br><br>`SUB name;graphic;(start_x, start_y);(end_x,end_y)` |
| **ZEROGROB** | Creates a blank graphic with given height.<br><br>`ZEROGROB name;width;height;graphic` |

## Loop Commands

A programming structure allows a program to control how it should execute depending on given conditions or the values of particular arguments. The HP 38G has two kinds of control structures:

- Branch structures.
- Loop structures

**DO...UNTIL ...END**

`Do ... Until ... End` is a loop structure that executes the *loop-clause* repeatedly until *test-clause* returns a true (nonzero) result. Because the test is executed *after* the loop-clause, the loop-clause is always executed at least once. Its syntax is:

```
DO loop-clause UNTIL test-clause END
```

**WHILE... REPEAT... END**

`While ... Repeat ... End` is a loop structure that repeatedly evaluates *test-clause* and executes *loop-clause* sequence if the test is true. Because the test-clause is executed before the loop-clause, the loop-clause is not executed if the test is initially false. Its syntax is:

```
WHILE test-clause REPEAT loop-clause END
```

**FOR I ...TO ...STEP ...END**

```
FOR name=start-expression TO end-expression
STEP INCREMENT;
  loop-clause END
```

**Example**

```
FOR I=1 to 300
 STEP 30;
 BEEP 800+I; .5:
END
```

**BREAK**

Terminates loop.

## Matrix Commands

The Matrix commands use the matrix 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;[value$_1$,...,value$_n$];column_number*

**ADDROW** Add Row. Inserts *values* into a row before *row_number* in the specified matrix. You enter the *values* as a vector. The values must be separated by commas and the number of values must be the same as the number of columns in the matrix name.

ADDROW *name;[value$_1$,...,value$_n$];row_number*

**DELCOL** Delete Column. Deletes the specified column from the specified matrix.

DELCOL *name;column_number*

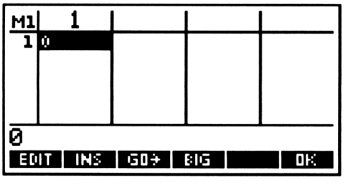
**DELROW** Delete Row. Deletes the specified row from the specified matrix.

DELROW *name;row_number*

**EDITMAT** Starts the Matrix Editor and displays the specified matrix. Returns to the program when user presses {{OK}}.

EDITMAT *name*

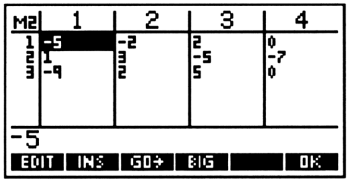
**Example** EDITMAT M1
Starts the Matrix Editor on matrix M1.



**RANDMAT** Creates random matrix with number of rows and columns you specify in *rows*, *columns*, and stores the result in *name* (name must be `M0...M9`). The entries will be integers ranging from -9 to 9.

```
RANDMAT name;rows;columns
```

**Example:**
```
RANDMAT M2;3;4:
EDITMAT M2:
```
Creates a Matrix in M2 with 3 rows and 4 columns; then starts the Matrix Editor and displays matrix M2.




**REDIM** Redimensions the specified matrix to *size*. For a matrix, *size* is a list of two integers {*n1*,*n2*}. For a vector, *size* is a list containing one integer {*n*}.

```
REDIM name;{size}
```

**REPLACE** Replaces portion of matrix or vector stored in *name* with another starting at position *start*. *Start* for a matrix is a list containing two numbers; for a vector, it is a single number. Replace also works for lists and graphics.

```
REPLACE name;start;object
```

**SCALE** Multiplies the specified *row_number* of the specified matrix by *value*.

```
SCALE name;value;row_number
```

**SCALEADD** Multiplies the first specified row of the matrix in *name* by *value*, then adds this result to the second specified row, and stores the result in *name*.

```
SCALEADD name;value;row1;row2
```

| | |
|---|---|
| **SUB** | Extracts a *sub-object*—a portion of a list, matrix, or graphic from *object* and stores it into *name*. `Start` and `end` are each specified using a list with two numbers for matrix, using a number for vector or lists, or using (x,y) for graphics.<br>`SUB name;object;start;end` |
| **SWAPCOL** | Swap Columns. Exchanges *column1* and *column2* of the specified matrix.<br>`SWAPCOL name;column1;column2` |
| **SWAPROW** | Swap Rows. Exchanges *row1* and *row2* in the specified matrix.<br>`SWAPROW name;row1;row2` |

## Print Commands

These commands print to an HP infrared printer.

| | |
|---|---|
| **PRDISPLAY** | Prints the contents of the display.<br>`PRDISPLAY` |
| **PRHISTORY** | Prints all objects in the stack history.<br>`PRHISTORY` |
| **PRVAR** | Prints name and contents of *variable_name*.<br>`PRVAR variable_name`<br>You can also use the PRIVAR command to print the contents of a program or a note.<br>`PRVAR program_name;PROG`<br>`PRVAR note_name;NOTE` |

## Prompt Commands

You can use the following commands to prompt users for input during your program—or to provide information to users.

**BEEP**

Beeps at the at the frequency and time you specify.

```
BEEP frequency;time_in_seconds
```

**Example** `BEEP 1024;5`
Creates a 5-second beep at 1024 Hz.

**CHOOSE**

Where *name* is the name of the variable from which the number of the initially-highlighted item is retrieved—and into which the number of the chosen item will be stored. *Prompt* is the top-of-box prompt or null (meaning no prompt), and *item-1* through *item-n* are the text items to be displayed. CHOOSE displays a choose box and sets the specified variable to real number 0 through n corresponding to whether the choose box is canceled (0), or an item is chosen (1 through n).

```
CHOOSE name;prompt,item-1...;item-n
```

**Example**

```
3{{STO▶}}A:CHOOSE A; "COMIC STRIPS";
"DILBERT";
"CALVIN&HOBBES";
"BLONDE";
```

**DISP** Displays *text_item* and a value in display *line_number*. A text_item consists of any number of expressions and quoted strings of text. The expressions are evaluated and turn into strings. Lines are numbered from the top of the screen, 1 being the top and 7 being the bottom.

DISP *line_number;text_item*

**Example** 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, simple 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**

5.151995{{STO▶}}DATE (sets the date to May 15, 1995).

10.1500{{STO▶}}TIME (sets the time to 10:15 am).

**EDITMAT** Matrix Editor. Opens the Matrix editor for the specified matrix. Returns to the program when user presses {{OK}}.

EDITMAT *matrixname*

**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 are designated 1 for unshifted, 2 for shifted, 4 for alpha-shifted, and 5 for both alpha-shifted and shifted.

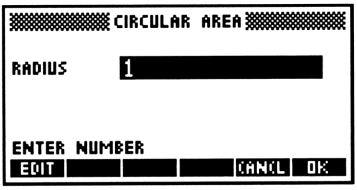
GETKEY *name*

**INPUT** Suspends program execution, prompt the user with *title*, *label*, and *help*, initializes the command line with *default*, and saves the resulting input in *name*. Use ■ [CHARS] to type the quote marks " ".

```
INPUT name;title,label;help;default
```

**Example**

```
INPUT R; "Circular Area";
       "Radius";
       "Enter Number";1:
```

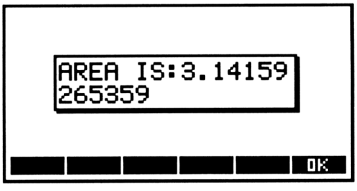



**MSGBOX** Suspends program execution and displays a message box containing *text_item*. A text_item consists of any number of expressions and quoted strings of text. The expressions are evaluated and turned into strings of text. For example, "Area is" 2+2 becomes Area is 4. Use ■ [CHARS] to type the quote marks " ".

```
MSGBOX text_item:
```

**Example**

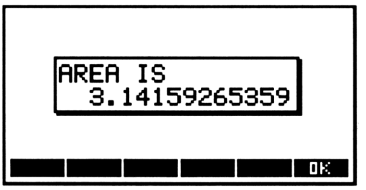
```
1{{STO▶}}A:
MSGBOX "AREA IS: ";π*A^2:
```



You can also use the NoteText variable to provide text arguments. This can be used to insert line breaks. For example, press ■ [NOTE] and type AREA IS [ENTER].

**Example**

```
MSGBOX NoteText " " π*A^2:
```




**WAIT** Halts program execution for specified number of seconds.

```
WAIT seconds
```

## Stat-One and Stat-Two Commands

Analysis of one-variable and two-variable statistical data. You can refer to chapter 5 for complete definitions of these variables.

### Stat-One Commands

**DO1VSTATS** Calculates STATS using *datasetname* and stores the results in corresponding variables: NΣ, TotΣ, MeanΣ, PVarΣ, SVarΣ, PSDev, SSDev, MinΣ, Q1, Median, Q3, and MaxΣ. *Datasetname* can be H1, H2, ..., or H5. *Datasetname* must define at least two data points.

```
DO1VSTATS datasetname
```

**RANDSEED** Sets random number seed to *value*. The random number seed is used in the calculation of random numbers by the RANDOM function.

```
RANDSEED value
```

**SETFREQ** Defines *datasetname* frequency according to *expression*. *Datasetname* can be H1, H2,..., or H5.

```
SETFREQ datasetname;expression
```

**SETSAMPLE** Defines *datasetname* sample according to *expression*. *Datasetname* can be H1, H2,..., or H5.

```
SETSAMPLE datasetname;expression
```

### Stat-Two Commands

**DO2VSTATS** Calculates STATS using *datasetname* and stores the results in corresponding variables: MeanX, ΣX, ΣX2, MeanY, ΣY, ΣY2, ΣXY, Corr, Cov, and Fit. *Datasetname* can be S1, S2,..., or S5. *Datasetname* must define at least four pairs of data points.

```
DO2VSTATS datasetname
```

**SETDEPEND** Defines *datasetname* dependent according to expression. *Datasetname* can be S1, S2, ..., or S5.

```
SETDEPEND datasetname;expression
```

**SETINDEP** Defines *datasetname* independent according to expression. *Datasetname* can be S1, S2, ..., or S5.

```
SETINDEP datasetname;expression
```

# Storing and Retrieving Variables in Programs

The HP 38G 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 or 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.

## The Variable Menu

You use the Variable menu ([VAR]) to retrieve either Home variables or aplet variables.

**To retrieve a Home variable**

You can use this procedure to retrieve either the variable *name* or the variable *value* into your program.

1. Press [VAR] to open the Variable menu.
2. If necessary, press {{HOME■}} to open the list of aplet variables.

   The left side of the display shows the variable categories and the right side shows the variable names.

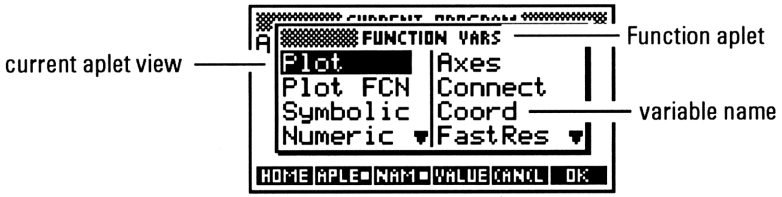

3. Select a Home variable category.
4. Select a Home variable name.
5. Press {{NAM■}} {{OK}} to retrieve the *name* of the variable.
   *or*
   Press {{VALU■}} {{OK}} to retrieve the *value* of the variable.

**To retrieve an aplet variable**

You can use this procedure to retrieve either the variable name or the variable value into your program.

1. Press [VAR] to open the Variable menu.
2. If necessary, press {{APLE■}} to open the list of aplet variables.
3. Select an aplet view.

   Each aplet variables is associated with a view: Numeric or Numeric Setup, Symbolic or Symbolic Setup, Plot or Plot Setup, Note, or Sketch.




4. Select an aplet variable name.
5. Press {{NAM■}} {{OK}} to retrieve the *name* of the variable.
   *or*
   Press {{VALU■}} {{OK}} to retrieve the *value* of the variable.

## Plot-View Variables

The following aplet variables are available in Plot View. Not all variables are available in every aplet. S1fit-S5fit, for example, are only available in Statistics. *Under each variable name is a list of the aplets where the variable can be used.*

| | |
|---|---|
| **Area**<br>*Function* | Contains the last value found by Area operation in Plot-FCN menu. |
| **Axes**<br>*All Aplets* | Turns axes-drawing on or off.<br>From Plot Setup, check (or uncheck) _AXES.<br>*or*<br>In a program, type<br>1 {{STO▶}}Axes to turn axes-drawing on (default).<br>0 {{STO▶}}Axes to turn axes-drawing off. |
| **Connect**<br>*Function*<br>*Parametric*<br>*Polar*<br>*Solve*<br>*Statistics* | Draws lines between successively plotted points.<br>From Plot Setup, check (or uncheck) _CONNECT.<br>*or*<br>In a program, type<br>1 {{STO▶}}Connect to connect plotted points (default, except in Statistics where the default is off).<br>0 {{STO▶}}Connect not to connect plotted points. |
| **Coord**<br>*Function*<br>*Parametric*<br>*Polar*<br>*Sequence*<br>*Solve*<br>*Statistics* | Turns the coordinate-display mode in Plot view on or off.<br>From Plot view, press {{X,Y}}<br>*or*<br>In a program, type<br>1 {{STO▶}}Coord to turn coordinate display on (default).<br>0 {{STO▶}}Coord to turn coordinate display off. |

| | |
|---|---|
| **Extremum**<br>*Function* | Contains the last value found by Extremum operation in the Plot-FCN menu. |
| **FastRes**<br>*Function*<br>*Solve* | Toggles resolution between plotting in every other column (faster), or plotting in every column (more detail).<br>From Plot Setup, choose Faster or More Detail.<br>*or*<br>In a program, type<br>`1 {{STO▶}}FastRes` for faster (default).<br>`0 {{STO▶}}FastRes` for more detail. |
| Grid<br>*All Aplets* | Turns the background grid in Plot View on or off.<br>From Plot Setup, check (or uncheck) `_GRID`.<br>*or*<br>In a program, type<br>`1 {{STO▶}}Grid` to turn the grid on.<br>`0 {{STO▶}}Grid` to turn the grid off (default). |
| Hmin/Hmax<br>*Statistics* | Defines minimum and maximum values for histogram bars.<br>From Plot Setup for one-variable statistics, set value for `HRNG`.<br>*or*<br>In a program, type<br>*n* `{{STO▶}}Hmin`<br>*n* `{{STO▶}}Hmax` |
| Hwidth<br>*Statistics* | Sets the width of histogram bars.<br>In a program, type<br>*n* `{{STO▶}}Hwidth` |
| Indep<br>*All Aplets* | Defines the value of the independent variable used in Tracing mode.<br>In a program, type<br>*n* `{{STO▶}}Indep` |

| | |
|---|---|
| **InvCross**<br><br>*All Aplets* | Toggles between solid crosshairs or inverted crosshairs. (Inverted is useful if background is solid).<br><br>From Plot Setup, check (or uncheck) `_InvCross`<br>*or*<br>In a program, type<br><br>`1 {{STO▶}}InvCross` to invert the crosshairs.<br>`0 {{STO▶}}InvCross` for solid crosshairs (default). |
| **Isect**<br><br>*Function* | Contains the last value found by Intersection operation in the Plot-FCN menu. |
| **Labels**<br><br>*All Aplets* | Draws labels in Plot view showing X and Y ranges.<br><br>From Plot Setup, check (or uncheck) `_Labels`<br>*or*<br>In a program, type<br><br>`1 {{STO▶}}Labels` to turn labels on.<br>`0 {{STO▶}}Labels` to turn labels off (default). |
| **Nmin / Nmax**<br><br>*Sequence* | Defines the minimum and maximum independent variable values. Appears as the NRNG fields in the Plot Setup input form.<br><br>From Plot Setup, enter values for NRNG.<br>*or*<br>In a program, type<br><br>*n* `{{STO▶}}Nmin`<br>*n* `{{STO▶}}Nmax` |
| **Recenter**<br><br>*All Aplets* | Recenters at the crosshairs locations when zooming.<br><br>From Plot-Zoom-Set Factors, check (or uncheck) `_Recenter`<br>*or*<br>In a program, type<br><br>`1 {{STO▶}}Recenter` to turn recenter on (default).<br>`0 {{STO▶}}Recenter` to turn recenter off. |
| **Root**<br><br>*Function* | Contains the last value found by Root operation in the Plot-FCN menu. |

| | |
|---|---|
| **S1mark-S5mark**<br>*Statistics* | Defines the mark to use for statistics 2-variable scatter plots.<br>From Plot Setup for two-variable statistics, `S1mark-S5mark`, then choose a mark.<br>*or*<br>In a program, type<br>*n* {{`STO▶`}}`S1mark` |
| **SeqPlot**<br>*Sequence* | Toggles type of sequence plot: Stairstep or Cobweb.<br>From Plot Setup, select SeqPlot, then choose `Stairstep` or `Cobweb`.<br>*or*<br>In a program, type<br>1 {{`STO▶`}}`SeqPlot` for Stairstep (default).<br>2 {{`STO▶`}}`SeqPlot` for Cobweb. |
| **Simult**<br>*Function*<br>*Parametric*<br>*Polar*<br>*Sequence* | Turns simultaneous function-plotting on or off. When simultaneous function-plotting is on, sequential function-plotting is off.<br>From Plot Setup, check (or uncheck) `_SIMULT`<br>*or*<br>In a program, type<br>1 {{`STO▶`}}`Simult` for on (default).<br>0 {{`STO▶`}}`Simult` for off. |
| **Slope**<br>*Function* | Contains the last value found by Slope operation in the Plot-FCN menu. |
| **StatPlot**<br>*Statistics* | Toggles type of 1-variable statistics plot between Histogram or BoxWhisker.<br>From Plot Setup, select StatPlot, then choose `Histogram` or `BoxWhisker`.<br>*or*<br>In a program, type<br>1 {{`STO▶`}}`StatPlot` for Histogram (default).<br>2 {{`STO▶`}}`StatPlot` for BoxWhisker. |

| | |
|---|---|
| **θmin/θmax**<br>*Polar* | Defines the minimum and maximum independent values. Appears as the θrng field in the Plot Setup input form.<br>From the Plot Setup input form, enter values for θrng.<br>*or*<br>In a program, type<br>*n* {{STO▶}}θmin<br>*n* {{STO▶}}θmax |
| **❑step**<br>*Polar* | Defines the step size for an independent variable.<br>From the Plot Setup input form, enter values for ❑STEP.<br>*or*<br>In a program, type<br>*n* {{STO▶}}θstep |
| **Tmin / Tmax**<br>*Parametric* | Defines the minimum and maximum independent variable values. Appears as the TRNG fields in the Plot Setup input form.<br>From Plot Setup, enter values for TRNG.<br>*or*<br>In a program, type<br>*n* {{STO▶}}Tmin<br>*n* {{STO▶}}Tmax |
| **Tracing**<br>*All Aplets* | Turns Tracing mode on or off in Plot view.<br>In a program, type<br>1 {{STO▶}}Tracing to turn Tracing mode on (default).<br>0 {{STO▶}}Tracing to turn Tracing mode off. |
| **Tstep**<br>*Parametric* | Defines the step size for an independent variable.<br>From the Plot Setup input form, enter values for TSTEP.<br>*or*<br>In a program, type<br>*n* {{STO▶}}Tstep |

| | |
|---|---|
| **Xcross**<br>*All Aplets* | Defines the horizontal coordinate of crosshairs. Only works with TRACE off.<br>In a program, type<br>*n* {{STO▶}}Xcross |
| **Ycross**<br>*All Aplets* | Defines the vertical coordinate of crosshairs. Only works with TRACE off.<br>In a program, type<br>*n* {{STO▶}}Ycross |
| **Xtick**<br>*All Aplets* | Defines the distance between tick marks for the horizontal axis.<br>From the Plot Setup input form, enter a value for Xtick.<br>*or*<br>In a program, type<br>*n* {{STO▶}}Xtick |
| **Ytick**<br>*All Aplets* | Defines the distance between tick marks for the vertical axis.<br>From the Plot Setup input form, enter a value for Ytick.<br>*or*<br>In a program, type<br>*n* {{STO▶}}Ytick |
| **Xmin / Xmax**<br>*All Aplets* | Defines the minimum and maximum horizontal values of the plot screen. Appears as the XRNG fields (horizontal range) in the Plot Setup input form.<br>From Plot Setup, enter values for XRNG.<br>*or*<br>In a program, type<br>*n* {{STO▶}}Xmin<br>*n* {{STO▶}}Xmax |

| | |
|---|---|
| **Ymin / Ymax**<br>*All Aplets* | Defines the minimum and maximum vertical values of the plot screen. Appears as the YRNG fields (vertical range) in the Plot Setup input form.<br>From Plot Setup, enter the values for YRNG.<br>*or*<br>In a program, type<br>*n* {{STO▶}}Ymin<br>*n* {{STO▶}}Ymax |
| **Xzoom**<br>*All Aplets* | Sets the horizontal zoom factor.<br>From Plot-ZOOM-Set Factors, enter the value for XZOOM.<br>*or*<br>In a program, type<br>*n* {{STO▶}}XZOOM (default zoom factor is 4). |
| **Yzoom**<br>*All Aplets* | Sets the vertical zoom factor.<br>From Plot-ZOOM-Set Factors, enter the value for YZOOM.<br>*or*<br>In a program, type<br>*n* {{STO▶}}YZOOM (default zoom factor is 4). |

## Symbolic-View Variables

The following aplet variables are available in Symbolic View.

| | |
|---|---|
| **Angle**<br>*All Aplets* | Sets the angle mode.<br><br>From Symbolic Setup, choose `Degrees`, `Radians`, or `Grads` for angle measure.<br>*or*<br>In a program, type<br>`1 {{STO▶}} Angle` for Degrees.<br>`2 {{STO▶}} Angle` for Radians (default).<br>`3 {{STO▶}}Angle` for Grads. |
| **F1...F9, F0**<br>*Function* | Can contain any expression. Independent variable is X.<br><br>**Example**<br>`'SIN(X)'{{STO▶}}F1(X)'`<br><br>In the above example, you must put single quotes around the expression to keep it from being evaluated before it is stored. Use ■ [CHARS] to type the single quote mark. |
| **X1, Y1...X9,Y9**<br>**X0,Y0**<br>*Parametric* | Can contain any expression. Independent variable is T.<br><br>**Example**<br>`'SIN(4*T)'{{STO▶}}Y1(T):'2*SIN(6*T)'{{STO▶}}X1(T)` |
| **R1...R9, R0**<br>*Polar* | Can contain any expression. Independent variable is θ.<br><br>**Example**<br>`'2*SIN(2*θ)'{{STO▶}}R1(θ)` |
| **U1...U9, U0**<br>*Sequence* | Can contain any expression. Independent variable is N.<br><br>**Example**<br>`RECUSE (U,U(N-1)*N,1,2){{STO▶}}U1(N)` |

| | |
|---|---|
| **E1...E9, E0**<br>*Solve* | Can contain any equation or expression. *Independent variable is selected by highlighting it in Numeric View.*<br><br>**Example**<br>'X+Y*X-2=Y' {{STO▶}}E1 |
| **S1fit...S5fit**<br>*Statistics* | Defines the *type* of fit to be used by the {{FIT}} operation in Statistics (two-variable), Plot view. You set the type in Symbolic setup as follows:<br><br>Linear<br>LogFit<br>ExpFit<br>Power<br>QuadFit<br>Cubic<br>Logist<br>User defined<br><br>**Example**<br>CUBIC {{STO▶}}S2fit |

## Numeric-View Variables

The following aplet variables are available in Numeric View.

| | |
|---|---|
| **C1...C9, C0**<br>*Statistics* | C0 through C9, and C0 for columns of data. Can contain lists. |
| **Digits**<br>*All Aplets* | Number of decimal places to use for Number format.<br>From Solve-Numeric_Setup, enter a value in the second field of Number Format.<br>*or*<br>In a program, type<br>*n* {{STO▶}}Digits where 0 ≤ n ≤ 11. |
| **Format**<br>*All Aplets* | Defines the number display format.<br>From Solve-Numeric_Setup, choose Standard, Fixed, Scientific, Engineering, or Fraction in the Number Format field.<br>*or*<br>In a program, type<br>1 {{STO▶}}Format for Standard.<br>2 {{STO▶}}Format for Fixed.<br>3 {{STO▶}}Format for Scientific.<br>4 {{STO▶}}Format for Engineering.<br>5 {{STO▶}}Format for Fraction. |
| **NumCol**<br>*All Aplets* | Defines the highlighted column in Numeric view.<br>In a program, type<br>*n* {{STO▶}}NumCol |
| **NumFont**<br>*Function*<br>*Parametric*<br>*Polar*<br>*Sequence*<br>*Statistics* | Toggles the font size in Numeric view. Does not appear in the Num Setup input form. Corresponds to the {{BIG}} key in Numeric view.<br>In a program, type<br>0 {{STO▶}}NumFont for small (default).<br>1 {{STO▶}}NumFont for big. |

| | |
|---|---|
| **NumIndep**<br>*Function*<br>*Parametric*<br>*Polar*<br>*Sequence* | List of independent values used by Build Your Own Table.<br>In a program, type<br>`list {{STO▶}}NumIndep` |
| **NumRow**<br>*All Aplets* | Defines the highlighted row in Numeric view.<br>In a program, type<br>*n* {{STO▶}}NumRow |
| **NumStart**<br>*Function*<br>*Parametric*<br>*Polar*<br>*Sequence* | Defines the starting value for table in Numeric View.<br>From Num Setup, enter a value for NUMSTART.<br>*or*<br>In a program, type<br>n {{STO▶}}NumStart. |
| **NumStep**<br>*Function*<br>*Parametric*<br>*Polar*<br>*Sequence* | Defines the step size (increment value) for an independent variable in Numeric View.<br>From Num Setup, enter a value for NUMSTEP.<br>*or*<br>In a program, type<br>n {{STO▶}}NumStep |
| **NumType**<br>*Function*<br>*Parametric*<br>*Polar*<br>*Sequence* | Choose a table format.<br>From Num Setup, choose Automatic or Build Your Own.<br>*or*<br>In a program, type<br>0 {{STO▶}}NumType for Build Your Own.<br>1 {{STO▶}}NumType for Automatic (default). |
| **NumZoom**<br>*Function*<br>*Parametric*<br>*Polar*<br>*Sequence* | Defines the Zoom factor.<br>From Num Setup, type in a value for NUMZOOM.<br>*or*<br>In a program, type<br>*n* {{STO▶}}NumZoom |

| | |
|---|---|
| **StatMode**<br>*Statistics* | Toggles mode between 1-variable and 2-variable statistics. Does not appear in the Plot Setup input form. Corresponds to the {{1VAR}} and {{2VAR}} keys in Numeric View.<br>In a program, type<br>1 {{STO▶}}StatMode for 1VAR.<br>2 {{STO▶}}StatMode for 2VAR. |

## Note Variables

The following aplet variable is available in Note View.

| | |
|---|---|
| **NoteText**<br>*All Aplets* | Use NoteText to recall text previously entered in Note view. |

## Sketch Variables

The following aplet variables are available in Sketch View.

| | |
|---|---|
| **Page**<br>*All Aplets* | Defines a *page* in a sketch set. A sketch set can contain up to 10 graphics. The graphics can be viewed one at a time using the {{▲PAGE}} and {{PAGE▼}} keys.<br>The Page variable references the currently-displayed page of a sketch set.<br>In a program, type<br>*graphic_variable* {{STO▶}}Page |
| **PageNum**<br>*All Aplets* | Index for referring to a particular page of the sketch set (in Sketch View).<br>In a program, type<br>*n*{{STO▶}}PageNum |

# Menu Maps of the VAR menu

## Home Variables

| Complex | Graphic | Library | List | Matrix |
|---|---|---|---|---|
| Z1...Z9, Z0 | G1...G9, G0 | Function<br>Parametric<br>Polar<br>Sequence<br>Solve<br>Statistics<br>*User-named* | L1...L9, L0 | M1...M9, M0 |
| **Modes**<br>Ans<br>Date<br>HAngle<br>HDigits<br>HFormat<br>Ierr<br>Time | **Notepad**<br>*User-named* | **Program**<br>Editline<br>*User-named* | **Real**<br>A...Z, θ | |

## Function Variables

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

## Parametric Variables

| Plot | | Symbolic | | Numeric | Note |
|---|---|---|---|---|---|
| Axes | Tstep | Angle | X6 | Digits | NoteText |
| Connect | Xcross | X1 | Y6 | Format | |
| Coord | Ycross | Y1 | X7 | NumCol | |
| Grid | Xtick | X2 | Y7 | NumFont | **Sketch** |
| Indep | Ytick | Y2 | X8 | NumIndep | Page |
| InvCross | Xmin | X3 | Y8 | NumRow | PageNum |
| Labels | Xmax | Y3 | X9 | NumStart | |
| Recenter | Ymin | X4 | Y9 | NumStep | |
| Simult | Ymax | Y4 | X0 | NumType | |
| Tmin | Xzoom | X5 | Y0 | NumZoom | |
| Tmax | Yzoom | Y5 | | | |
| Tracing | | | | | |

## Polar Variables

| Plot | | Symbolic | Numeric | Note |
|---|---|---|---|---|
| Axes | Xcross | Angle | Digits | NoteText |
| Connect | Ycross | R1 | Format | |
| Coord | Xtick | R2 | NumCol | **Sketch** |
| Grid | Ytick | R3 | NumFont | Page |
| Indep | Xmin | R4 | NumIndep | PageNum |
| InvCross | Xmax | R5 | NumRow | |
| Labels | Ymin | R6 | NumStart | |
| Recenter | Ymax | R7 | NumStep | |
| Simult | Xzoom | R8 | NumType | |
| θmin | Yxoom | R9 | NumZoom | |
| θmax | | R0 | | |
| θstep | | | | |
| Tracing | | | | |

## Sequence Variables

| Plot | | Symbolic | Numeric | Note |
|---|---|---|---|---|
| Axes | Xcross | Angle | Digits | NoteText |
| Coord | Ycross | U1 | Format | |
| Grid | Xtick | U2 | NumCol | |
| Indep | Ytick | U3 | NumFont | **Sketch** |
| InvCross | Xmin | U4 | NumIndep | Page |
| Labels | Xmax | U5 | NumRow | PageNum |
| Nmin | Ymin | U6 | NumStart | |
| Nmax | Ymax | U7 | NumStep | |
| Recenter | Xzoom | U8 | NumType | |
| SeqPlot | Yzoom | U9 | NumZoom | |
| Simult | | U0 | | |
| Tracing | | | | |

## Solve Variables

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

## Statistics Variables

| Plot | Symbolic | Numeric | Stat-One | Stat-Two |
|---|---|---|---|---|
| Axes | Angle | C0,...C9 | MaxΣ | Corr |
| Connect | S1fit | Digits | MeanΣ | Cov |
| Coord | S2fit | Format | Median | Fit |
| Grid | S3fit | NumCol | MinΣ | MeanX |
| Hmin | S4fit | NumFont | NΣ | MeanY |
| Hmax | S5fit | NumRow | Q1 | RelErr |
| Hwidth | | StatMode | Q3 | ΣX |
| Indep | | | PSDev | ΣX2 |
| InvCross | | **Note** | SSDev | ΣXY |
| Labels | | NoteText | PVarΣ | ΣY |
| Recenter | | | SVarΣ | ΣY2 |
| S1mark | | **Sketch** | TotΣ | |
| S2mark | | Page | | |
| S3mark | | PageNum | | |
| S4mark | | | | |
| S5mark | | | | |
| StatPlot | | | | |
| Tracing | | | | |
| Xcross | | | | |
| Ycross | | | | |
| Xtick | | | | |
| Ytick | | | | |
| Xmin | | | | |
| Xmax | | | | |
| Ymin | | | | |
| Ymax | | | | |
| Xzoom | | | | |
| Yxoom | | | | |

# 9

# Reference Information

This chapter covers the following topics:

- Regulatory information
- Warranty information
- Service information
- Battery information
- How to reset the calculator
- Glossary
- Selected status messages

## Regulatory Information

**U.S.A.**

This Handheld Calculator complies with the limits for a class B digital device as specified in Part 15 of FCC Rules, which provide reasonable protection against harmful interference in a residential installation. This Handheld Calculator generates and uses radio frequency energy and may interfere with radio and television reception. In the unlikely event that there is interference to radio or television reception (which can be determined by turning the calculator off and on), try the following :

- Reorient or relocate the receiving antenna (radio or television).
- Relocate the calculator with respect to the receiver.

Consult your dealer or an experienced radio/television technician for help.

**Canada**

This Class B digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numérique de la classe B respecte toutes les exigences du Règlement sur le matériel brouilleur du Canada.

## Europe

DECLARATION OF CONFORMITY
according to ISO/IEC Guide 22 and EN 45014

| | |
|---|---|
| **Manufacturer's name** | Hewlett-Packard Company |
| **Manufacturer's address** | Asia-Pacific Personal Computer Division<br>72 Bendemeer Road #01/01 #07/01<br>Singapore 1233 |

**declares that the following product**

| | |
|---|---|
| **Product name** | Handheld Calculator |
| **Model number** | HP 38G |
| **Product options** | All. |

**conforms to the following product specifications**

| | |
|---|---|
| **Safety** | IEC 950 : 1986+A1,A2 / EN 60950 (1988)+A1,A2 |
| **EMC** | CISPR 22 : 1985 / EN 55022 : 1988 : Class B(1)<br>EN 50082-1 : 1992<br>IEC 801-2 : 1991 / prEN 55024-2 : 1992 - 4kV CD, 8kV AD<br>IEC 801-3 : 1984 / prEN 55024-3 : 1991 - 3V/m<br>IEC 801-4 : 1988 / prEN 55024-4 : 1992 - 0.5 kV signal lines |
| **Supplementary information** | The product herewith complies with the requirements of the EMC Directive 89/336/EEC.<br>(1) The product was tested in a typical configuration with Hewlett-Packard personal computer peripherals. |

Seah Beng Geok

Singapore,
30 December 1994

Seah Beng Geok, Quality Assurance Manager

European Contact : your local Hewlett-Packard Sales and Service Office *or* Hewlett-Packard GmbH, Department Technical Relations Europe, Herrenberger Str. 130, D71034 Böblingen. (Fax : +49-7031-143143)

# Limited One-Year Warranty

**What is Covered**

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

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

**What is Not Covered**

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

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

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

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

**In Australia and the U.K. :**

The above disclaimers and limitations shall not apply to consumer transactions in Australia and the United Kingdom and shall not affect the statutory rights of consumers.

# Service

**Environmental Limits**

- 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 operated at 4.5V dc, 60mA maximum.

**Customer Support**

**In the United States.** If you have technical questions about how to use the product that are not covered in this guide, you can contact

Hewlett-Packard Calculator Support
1000 NE Circle Blvd.
Corvallis OR 97330 U.S.A.
(503) 715-2004; Fax (503) 715-3628
Mon.-Fri. 8:00 am–3:00 pm Pacific time. Closed holidays.

Allow two weeks for replies to mailed or faxed questions.

**Outside the United States.** Your authorized Hewlett-Packard dealer is committed to providing after-sale support. Authorized dealers are able to provide local, personal support, and they are backed by the resources of the Hewlett-Packard Company.

**HP Electronic Information Service.** This computer service provides calculator information free of charge. You pay only for the phone call or Internet service. There are two ways to connect to this service from a computer :

- **Via modem** : (503)715-4448. It operates at 2400/9600/14400 baud, full duplex, no parity, 8 bits, 1 stop bit.
- **Via the Internet** : Access `hpcvbbs.external.hp.com` (or `192.6.221.13`) using telnet, ftp, or a World-Wide-Web browser (`http://hpcvbbs.external.hp.com`).

## Hardware Service

Contact Hewlett-Packard for diagnostic instructions and other service information before you send your calculator for repair.

**In the United States.** Send the calculator to the Corvallis Service Center listed on the inside of the back cover.

**Outside the U.S.** Contact your Hewlett-Packard dealer or sales office for the location of the nearest service center. *Do not ship the calculator for service without first contacting a Hewlett-Packard office.*

If local service is unavailable, you can ship the calculator to the Corvallis Service Center for repair. All shipping, reimportation arrangements, and customs costs are your responsibility.

**Service Charge.** Contact the Corvallis Service Center (inside back cover) for the standard out-of-warranty repair charges. This charge is subject to the customer's local sales or value-added tax wherever applicable.

Calculator products damaged by accident or misuse are not covered by the fixed charges. These charges are individually determined based on time and material.

**Shipping Instructions.** If your calculator requires service, ship it to the nearest authorized service center or collection point.

- Include your return address and a *detailed description* of the problem. Details should include error messages and any peripherals connected at the time of malfunction.
- Include proof of purchase date if the warranty has not expired.
- Include a purchase order, check, or credit card number plus expiration date (VISA or MasterCard) to cover the standard repair charge.
- Ship your calculator postage *prepaid* in adequate protective packaging to prevent damage. Shipping damage is not covered by the warranty, so we recommend that you insure the shipment.

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

**Service Agreements.** In the U.S., a support agreement is available for repair and service. For additional information, contact the Corvallis Service Center (inside back cover).

## HP Marketing Headquarters Outside the U.S.

Should you need to contact Hewlett-Packard, check your local telephone directory for the HP Sales and Service Office nearest you. If you cannot locate an HP office, contact one of the Worldwide HP Marketing Headquarters listed below.

| ASIA | LATIN AMERICA |
|---|---|
| Far East Sales Region Hdqtrs.<br>Hewlett-Packard Asia Ltd.<br>22nd Floor, West Tower, Bond Centre<br>GPO Box 863 Hong Kong | Hewlett-Packard Latin American Hdqtrs.<br>Monte Pelvoux 111<br>Lomas de Chapultepec<br>11000 México D.F. |
| **EUROPE** | **OTHER AREAS** |
| European Operations Hdqtrs.<br>Hewlett-Packard S.A.<br>150, route du Nant-d'Avril<br>CH 1217 Meyrin 2<br>Geneva, Switzerland | Hewlett-Packard Intercon Operations<br>3495 Deer Creek Road<br>P.O. Box 10495<br>Palo Alto, CA 94303-0896<br>USA |

# Batteries

When battery power is low, the ((•)) annunciator stays on, even when the calculator is off. There is also a warning message that appears when the calculator is on, `Warning: Low Bat`.

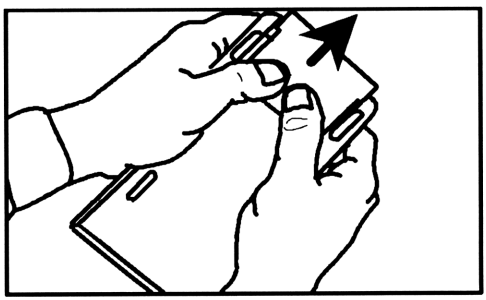
The HP 38G uses three AAA batteries. *Be sure all three are of the same brand and type.* Rechargeable batteries are *not* recommended because of their lower capacity and more sudden demise.

**■ To change the batteries**

1. Turn the calculator off and place the slide cover over the keyboard to keep from pressing keys.

**CAUTION** **Your calculator can lose memory if it is turned on while the batteries are being removed.**

2. Slide the battery compartment door off the rear of the calculator by pressing down on the dimple and pushing the door off.



3. Replace the batteries within 2 minutes to avoid memory loss. Position the fresh batteries according to the diagram inside the battery compartment–it is easiest to install the flat end of each battery first.

**CAUTION** **Do not mutilate, puncture, or dispose of batteries in fire. The batteries contain hazardous chemicals and can explode.**

# Resetting the HP 38G

If the calculator "locks up" and seems to be stuck, you must **reset** it. This is much like resetting a PC. It cancels certain operations, restores certain conditions, and clears temporary memory locations. However, it does *not* clear stored data (variables, aplet databases, programs) *unless* you use the procedure below, "To erase all memory and reset defaults".

**To reset using keystrokes**

Press and hold the [ON] key and the top-row left-middle key (top row, third from left) simultaneously, then release them.

**To reset using the reset hole**

If the calculator does not respond to the above key sequence, then

1. Turn the calculator over and locate the small hole below the bump (upper right). Insert the end of a straightened metal paper clip into the hole until it reaches the bottom. Hold it there for 1 second, then remove it.
2. Press [ON]. If necessary, press [ON]+*top-row,left-middle key.*

**To erase all memory and reset defaults**

If the calculator does not respond to the above resetting procedures, you might need to restart it by erasing all of memory. *You will lose everything you have stored.* All factory-default settings are restored.

1. Press and hold the [ON] key, the *leftmost top-row* key, and the *rightmost top-row* key simultaneously.
2. To *cancel* this process, release *only* the top-row keys, then press the *left-middle top-row* key.
3. To proceed, release all keys.

# Memory Specifications

- 32 KB of RAM (user memory).
- 512 KB of ROM (built-in software).

# 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 and no parentheses, such as `DISP` *expression*`;`*line#*.

**expression** A number, variable, or algebraic expression (numbers plus functions) that produces a value.

**function** An operation, possibly with arguments, that returns a result. It does not store results in variables. The arguments must be enclosed in parentheses and separated with commas (or periods in Comma mode), such as CROSS(*matrix1*,*matrix2*).

**Home** The basic starting point of the calculator. Go to Home to do calculations.

**Library** For aplet management : to start, save, reset, send and receive aplets.

**list** A set of values separated by commas (periods if the Decimal Mark is Comma) and enclosed in braces. Lists are commonly used to enter statistical data and to evaluate a function at multiple values. Created and manipulated by the List editor and catalog.

**matrix** A two-dimensional array of values separated by commas (periods if the Decimal Mark is Comma) and enclosed in nested brackets. Created and manipulated by the Matrix catalog and editor. Vectors are also handled by the Matrix catalog and editor.

**menu** A choice of operations given in the display. It can appear as a list or as a set of *menu-key labels* across the bottom of the display.

**menu keys** The top row of keys. Their operations depend on the current context. The labels in the bottom of the display

show the current meanings.

**note** Text that you write in the Notepad *or* in the Note view for a specific aplet.

**program** A reusable set of instructions that you record using the Program editor.

**sketch** A drawing that you make in the Sketch view for a specific aplet.

**variable** The name of a number, list, matrix, note, or graphic that is stored in memory. Use {{STO▶}} to store and use [VAR] to retrieve.

**vector** A one-dimensional array of values separated by commas (periods if the Decimal Mark is Comma) and enclosed in single brackets. Created and manipulated by the Matrix catalog and editor.

**views** The possible contexts for an *aplet* : Plot, Plot Setup, Numeric, Numeric Setup, Symbolic, Symbolic Setup, Sketch, Note, and special views like split screens.

# Selected Status Messages

| | |
|---|---|
| `Bad Argument Type` | Incorrect input for this operation. |
| `Bad Argument Value` | The value is out of range for this operation. |
| `Infinite Result` | Math exception, such as 1/0. |
| `Insufficient Memory` | You must recover some memory to continue operation. Delete one or more matrices, lists, notes,or programs (using catalogs), or custom (not built-in) aplets (using [LIB]). |
| `Insufficient Statistics Data` | Not enough data points for the calculation. For two-variable statistics there must be two columns of data, and each column must have at least four numbers. |
| `Invalid Dimension` | Array argument had wrong dimensions. |
| `Invalid Statistics Data` | Need two columns with equal numbers of data values. |
| `Invalid Syntax` | The function or command you entered does not include the proper arguments or order of arguments. The delimiters (parentheses, commas, periods, and semi-colons) must also be correct. Look up the function name in the index to find its proper syntax. |
| `Name Conflict` | The \| (where) function attempted to assign a value to the variable of integration or summation index. |
| `No Equations Checked` | You must enter and check an equation (Symbolic view) before evaluating this function. |
| `(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. |

## Selected Status Messages, continued

| | |
|---|---|
| `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 [LIB]). |

# Index

## Contacting Hewlett-Packard

**For Information about Using this Product.** If you have questions about how to use the product that are not covered in this guide, you can contact

Hewlett-Packard Calculator Support
1000 N.E. Circle Blvd.
Corvallis OR 97330 U.S.A.
(503) 715-2004; Fax (503) 715-3628
Mon.-Fri. 8:00am-3:00pm Pacific time. Closed holidays.

Allow two weeks for replies to mailed or faxed questions.

**For Hardware Service.** See appendix A of this user's guide for shipping instructions and information on obtaining service. *Before you send your product for service, please call HP Calculator Support (at the above number)* for diagnostic instructions and other service information.

Hewlett-Packard Corvallis Service Center
1030 N.E. Circle Blvd., Bldg. 11
Corvallis OR 97330 U.S.A.

**If You Are Outside the United States.** Contact your Hewlett-Packard dealer or sales office for customer support and service information.

**HP Electronic Information Service.** This computer service provides calculator information free of charge. You pay only for the phone call or Internet service. There are two ways to connect to this service from a computer:

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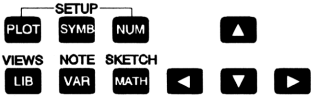
# Aplet Views

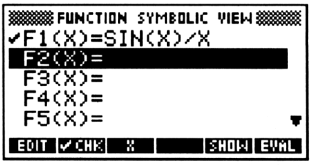



LIB

*library*


SYMB

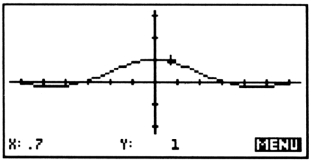
*symbolic*




■ [SETUP-PLOT]

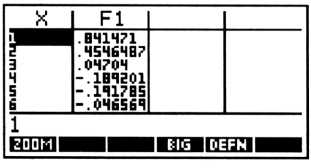

PLOT

*plot*




NUM

*numeric*




HEWLETT® PACKARD

**Part Number F1200-90013 Edition 1**

English
Printed in Singapore

May 1995