HP Prime Graphing Calculator

User Guide

Edition1
Part Number NW280-200X

Legal Notices

Product Regulatory & Environment Information

Product Regulatory and Environment Information is provided on the CD shipped with this product.

Printing History

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Preface

Manual conventions

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

- A key that initiates an unshifted function is represented by an image of that key:

  SIN, EEX, Settings, etc.

- A key combination that initiates a shifted unction (or inserts a character) is represented by the appropriate shift key (Shift or ALPHA) followed by the key for that function or character:

  Shift LN initiates the natural exponential function and ALPHA 3 inserts the pound character (#)

  The name of the shifted function may also be given in parentheses after the key combination:

  Shift Esc (Clear), Shift Symb (Setup)

- A key pressed to insert a digit is represented by that digit:

  5, 7, 8, etc.

- All fixed on-screen text—such as screen and field names—appear in bold:

  CAS Settings, **XSTEP**, **Decimal Mark**, etc.

- A menu item selected by touching the screen is represented by an image of that item:

  Sto ▸, OK, Cancel.

  Note that you must use your finger to select a menu item. Using a stylus or something similar will not select whatever is touched.

- Items you can select from a list, and characters on the entry line, are set in a non-proportional font, as follows:

  `Function`, `Polar`, `Parametric`, `Ans`, etc.

- Cursor keys are represented by ▲, ▼, ▶, and ◀. You use these keys to move from field to field on a screen, or from one option to another in a list of options.

- Error messages are enclosed inverted commas:

  "Syntax Error"

Notice

For hardware warranty information, please refer to the HP Prime Quick Start Guide.

Product Regulatory and Environment Information is provided on the CD shipped with this product.

1

Getting started

The HP Prime Graphing Calculator is an easy-to-use yet powerful graphing calculator designed for secondary mathematics education and beyond. It offers hundreds of functions and commands, and includes a computer algebra system (CAS) for symbolic calculations.

In addition to an extensive library of functions and commands, the calculator comes with a set of HP apps. A HP app is a special application designed to help you explore a particular branch of mathematics or to solve a problems of a particular type. For example, there is a HP app that will help you explore geometry and another to help you explore parametric equations. There are also apps to help you solve systems of linear equations and to solve time-value-of-money problems.

The HP Prime also has its own programming language you can use to explore and solve mathematical problems.

Functions, commands, apps and programming are covered in detail later in this guide. In this chapter, the general features of the calculator are explained, along with common interactions and basic mathematical operations.

Before starting

Charge the battery fully before using the calculator for the first time. To charge the battery, either:

- Connect the calculator to a computer using the USB cable that came in the package with your HP Prime. (The PC needs to be on for charging to occur.)
- Connect the calculator to a wall outlet using the HP-provided wall adapter.

When the calculator is on, a battery symbol appears in the title bar of the screen. Its appearance will indicate how much power the battery has. A flat battery will take approximately 4 hours to become fully charged.

⚠ Battery Warning

- To reduce the risk of fire or burns, do not disassemble, crush or puncture the battery; do not short the external contacts; and do not dispose of the battery in fire or water.
- To reduce potential safety risks, only use the battery provided with the calculator, a replacement battery provided by HP, or a compatible battery recommended by HP.
- Keep the battery away from children.
- If you encounter problems when charging the calculator, stop charging and contact HP immediately.

⚠ Adapter Warning

- To reduce the risk of electric shock or damage to equipment, only plug the AC adapter into an AC outlet that is easily accessible at all times.
- To reduce potential safety risks, only use the AC adapter provided with the calculator, a replacement AC adapter provided by HP, or an AC adapter purchased as an accessory from HP.

On/off, cancel operations

To turn on

Press On/Off to turn on the calculator.

To cancel

When the calculator is on, pressing the Esc/Clear key cancels the current operation. For example, it will clear whatever you have entered on the entry line. It will also close a menu and a screen.

To turn off

Press Shift On/Off (Off) turn the calculator off.

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

The Home View

Home view is the starting point for many calculations. Most mathematical functions are available in the Home view. Some additional functions are available in the computer algebra system (CAS). A history of your previous calculation is retained and you can re-use a previous calculation or its result.

To display Home view, press [Home/Settings].

The CAS View

CAS view is the where you use the computer algebra system. CAS view enables you to perform symbolic calculations. It is largely identical to Home view—it even has its own history of past calculations—but the CAS view offers some additional functions.

To display CAS view, press [CAS/Settings].

Protective cover

The calculator is provided with a slide cover to protect the display and keyboard. Remove the cover by grasping both sides of it and pulling down.

You can reverse the slide cover and slide it onto the back of the calculator. This will ensure that you do not misplace the cover while you are using the calculator.

To prolong the life of the calculator, always place the cover over the display and keyboard when you are not using the calculator.

The display

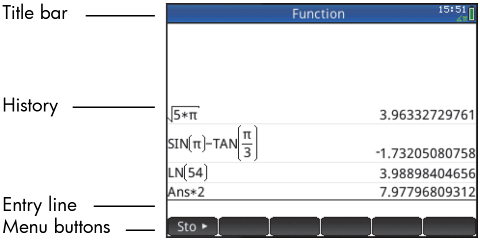
To adjust the contrast

To adjust the contrast of the display, press and hold [On/Off], then press the [+ Ans] or [− Base] key to increase or decrease the contrast. The contrast will change with each press of the [+ Ans] or [− Base] key.

To clear the display

- Press [Esc/Clear] or [On/Off] to clear the entry line.
- Press [Shift] [Esc/Clear] (Clear) to clear the entry line and the history.

Sections of the display



Home view has four sections (shown above). The **title bar** shows either the screen name or the name of the app you are currently using—`Function` in the example above. It also shows the time, a battery power indicator, and a number of symbols that indicate various calculator settings. These are explained below. The **history** displays a record of your past calculations. The **entry line** displays the object you are currently entering or modifying. The object could be a parameter, expression, list, matrix, line of programming code, etc. The **menu buttons** are options that are relevant to the current display. These options are selected by tapping the corresponding menu button. (Only a labeled button has a function.) You close a menu without making a selection from it by pressing Esc Clear.

Annunciators. Annunciators are symbols or characters that appear in the title bar. They indicate that certain settings are current, and also provide time and battery power information.

Annunciator	Meaning
∡° [Lime green]	The angle mode setting is currently degrees.
∡π [Lime green]	The angle mode setting is currently radians.

Annunciator	Meaning (Continued)
⬆S [Cyan]	The Shift key is active. The function shown in blue on a key will be activated when a key is pressed. Press Shift to cancel shift mode.
CAS [White]	You are working in CAS view, not Home view.
A...Z [orange]	The Alpha key is active. The character shown in orange on a key will be entered in *uppercase* when a key is pressed. See "Adding text" on page 20 for more information.
a...z [orange]	The Alpha–Shift key combination is active. The character shown in orange on a key will be entered in *lowercase* when a key is pressed. See "Adding text" on page 20 for more information.
⬆U [Yellow]	The user keyboard is active. All the following key presses will enter the customized objects associated with the key. See "The User Keyboard: Customizing key presses" on page 455 for more information.
1U [Yellow]	The user keyboard is active. The next key press will enter the customized object associated with the key. See "The User Keyboard: Customizing key presses" on page 455 for more information.
[Time]	Current time. The default is 24-hour format, but you can choose AM–PM format. See "Home settings" on page 27 for more information.

Annunciator	Meaning (Continued)
	Battery-charge indicator.

Navigation

The HP Prime offers two modes of navigation: touch and keys. In many cases, you can tap on an icon, field, menu, or object to select (or deselect) it. For example, you can open the Function app by tapping once on its icon in the Application Library. However, to open the Application Library, you will need to press a key: Apps Info.

Selections can often be made either by tapping or by using the keys. For instance, as well as tapping an icon in the Application Library, you can also press the cursor keys—▲, ▼, ◀, ▶—until the app you want to open is highlighted, and then press Enter ≈. In the Application Library, you can also type the first one or two letters of an app's name to highlight the app. Then either tap the app's icon or press Enter ≈ to open it.

Sometimes a touch or key–touch combination is available. For example, you can deselect a toggle option either by tapping twice on it, or by using the arrow keys to move to the field and then tapping a touch button along the bottom of the screen (in this case √).

Note that you must use your finger to select an item by touch. Using a stylus or something similar will not select whatever is touched.

Touch gestures

In addition to selection by tapping, there are other touch-related operations available to you:

To quickly move from page to page, **flick**:

> Place a finger on the screen and quickly swipe it in the desired direction (up or down).

To pan, **drag** your finger horizontally or vertically across the screen.

To quickly zoom in, make an **open pinch**:

> Place the thumb and a finger close together on the screen and move them apart. Only lift them from the screen when you reach the desired magnification.

To quickly zoom out, make an **closed pinch**:

> Place the thumb and a finger some distance apart on the screen and move them toward each other. Only lift them from the screen when you reach the desired magnification.

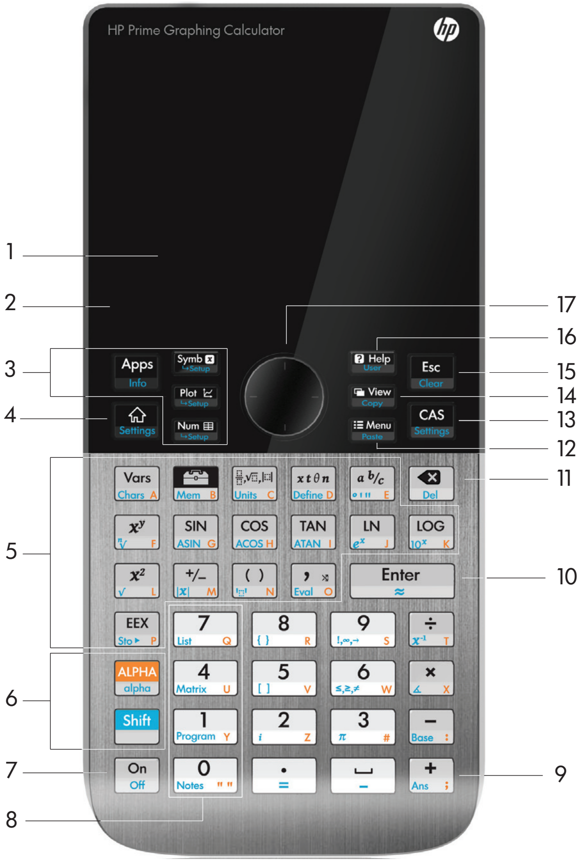
Note that pinching to zoom only works in applications that feature zooming (such as where graphs are plotted). In other applications, pinching will do nothing, or do something other than zooming. For example, in the Spreadsheet app, pinching will change the width of a column or the height of a row.

The keyboard

The numbers in the legend below refer to the parts of the keyboard described in the illustration below the legend.

Number	Feature
1	LCD and touch-screen: 320 × 240 pixels
2	Context-sensitive touch-button menu
3	HP Apps keys
4	Home view and preference settings
5	Common math and science functions
6	Alpha and Shift keys
7	On, Cancel and Off key
8	List, matrix, program, and note catalogs
9	Last Answer key (Ans)
10	Enter key
11	Backspace and Delete key

Number	Feature
12	Menu (and Paste) key
13	CAS (and CAS preferences) key
14	View (and Copy) key
15	Escape (and Clear) key
16	Help key
17	Rocker wheel (for cursor movement)



Context-sensitive menu

A context-sensitive menu occupies the bottom line of the screen.

The options available depend on the context, that is, the view you are in. Note that the menu items are activated by touch.

There are two types of buttons on the context-sensitive menu:

- menu button: tap to display a pop-up menu. These buttons have square corners along their top (such as Zoom in the illustration above).
- command button: tap to initiate a command. These buttons have rounded corners (such as Go To in the illustration above).

Entry and edit keys

The primary entry and edit keys are:

Keys	Purpose
0 to 9	Enter numbers
On or Esc	Cancels the current operation or clears the entry line.
Enter	Enters an input or executes an operation. In calculations, Enter acts like "=". When OK or Start is present as a menu key, Enter acts the same as pressing OK or Start.

Keys	Purpose (Continued)
[+/–]	For entering a negative number. For example, to enter –25, press [+/–] 25. *Note: this is not the same operation that is performed by the subtraction key* ([–]).
[Math template]	Math template: Displays a palette of pre-formatted templates representing common arithmetic expressions.
[xtθn]	Enters the independent variable (that is, either *X*, *T*, θ, or *N*, depending on the app that is current).
[Shift] [6]	Relations palette: Displays a palette of comparison operators and Boolean operators.
[Shift] [9]	Special symbols palette: Displays a palette of common math and Greek characters.
[Shift] [a b/c]	Automatically inserts the degree, minute, or second symbol according to the context.
[Del]	Backspace. Deletes the character to the left of the cursor. It will also return the highlighted field to its default value, if it has one.
[Shift] [Del]	Delete. Deletes the character to the right of the cursor.
[Shift] [Esc] (Clear)	Clears all data on the screen (including the history). On a settings screen—for example Plot Setup—returns all settings to their default values.

Keys	Purpose (Continued)
◀ ▶ ▲ ▼	Cursor keys: Moves the cursor around the display. Press Shift ▼ to move to the end of a menu or screen, or Shift ▲ to move to the start.
Shift Vars (Chars A)	Displays all the available characters. To enter a character, use the cursor keys to highlight it, and then tap OK. To select multiple characters, select one, tap Echo, and continue likewise before pressing OK. There are many pages of characters. You can jump to a particular Unicode block by tapping More and selecting the block. You can also flick from page to page.

Shift keys

There are two shift keys that you use to access the operations and characters printed on the bottom of the keys: Shift and ALPHA (alpha).

Key	Purpose
Shift	Press Shift to access the operations printed in blue on a key. For instance, to access the settings for Home view, press Shift Settings.
ALPHA (alpha)	Press the ALPHA key to access the characters printed in orange on a key. For instance, to type Z, press ALPHA and then press 2 (i Z). For a lowercase letter, press ALPHA Shift and then the letter. To type more than one letter, press ALPHA a second time to lock the alpha shift.

Adding text

The text you can enter directly is shown by the orange characters on the keys. These characters can only be entered in conjunction with the ALPHA and Shift keys. Both uppercase and lowercase characters can be entered, as explained in the following.

Keys	Effect
ALPHA	Makes the next character uppercase
ALPHA ALPHA	Lock mode: makes all characters uppercase until the mode is reset
Shift	With uppercase locked, makes the next character lowercase
ALPHA Shift	Makes the next character lowercase
ALPHA Shift ALPHA	Lock mode: makes all characters lowercase until the mode is reset
Shift	With lowercase locked, makes the next character uppercase
Shift ALPHA	With lowercase locked, makes all characters uppercase until the mode is reset
A	Reset uppercase lock mode
ALPHA ALPHA ALPHA ALPHA	Reset lowercase lock mode

You can also enter text (and other characters) by displaying the characters palette: Shift Vars.

Math keys

The most common math functions have their own key on the keyboard (or a key in combination with the Shift key).

Example 1: To calculate SIN(10), press SIN 10 and press Enter. The answer displayed is –0,544… (if your angle measure setting is radians).

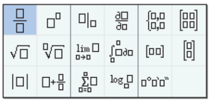
Example 2: To find the square root of 256, press Shift x^2 256 and press Enter. The answer displayed is 16. Notice that the Shift key initiates the operator represented in blue on the next key pressed (in this case √ on the x^2 key).

The mathematical functions not represented on the keyboard are on the **Math**, **CAS**, and **Catlg** menus (see chapter 20, "Functions and commands", starting on page 283).

Note that the order in which you enter operands and operators is determined by the entry mode. By default, the entry mode is *textbook*, which means that you enter operands and operators just as you would if you were writing the expression on paper. If your preferred entry mode is Reverse Polish Notation, the order of entry is different. (See chapter 2, "Reverse Polish Notation (RPN)", starting on page 43.)

Math template

The math template key (Units) helps you insert the framework for common calculations (and for vectors, matrices, and hexagesimal numbers). It displays a palette of pre-formatted outlines to which you add the constants, variables, and so on. Just tap on the template you want (or use the arrow keys to highlight it and press Enter). Then enter the components needed to complete the calculation.



Example: Suppose you want to find the cube root of 945:

1. In Home view, press Units.
2. Select $\sqrt[\square]{\square}$.

   The skeleton or framework for your calculation now appears on the entry line: $\sqrt[\square]{\blacksquare}$
3. Each box on the template needs to be completed:

3 ▶ 945

4. Press [Enter] to display the result: 9.813…

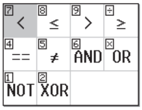
The template palette can save you a lot of time, especially with calculus calculations.

You can display the palette at any stage in defining an expression. In other words, you don’t need to start out with a template. Rather, you can embed one or more templates at any point in the definition of an expression.

Math shortcuts

As well as the math template, there are other similar screens that offer a palette of math characters. For example, pressing [Shift] [9] displays the special symbols palette, shown at the right. Select a character by tapping it (or scrolling to it and pressing [Enter]).

A similar palette—the relations palette—is displayed if you press [Shift] [9]. The palette displays operators useful in math and programming. Again, just tap the character you want.



Other math shortcut keys include [x t θ n]. Pressing this key inserts an *X*, *T*, θ, or *N* depending on what app you are using. (This is explained further in the chapters describing the apps.)

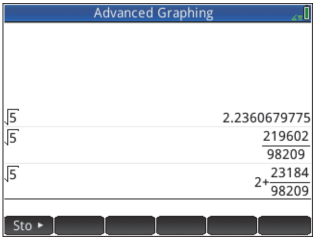
Similarly, pressing [Shift] [a b/c] enters a degree, minute, or second character. It enters ° if no degree symbol is part of your expression; enters ′ if the previous entry is a value in degrees; and enters ″ if the previous entry is a value in minutes. Thus entering:

36 [Shift] [a b/c] 40 [Shift] [a b/c] 20 [Shift] [a b/c]

yields 36°40′20″. See “Hexagesimal numbers” on page 23 for more information.

Fractions

The fraction key ([a b/c]) cycles through thee varieties of fractional display. If the current answer is the decimal fraction 5.25, pressing a b/c converts the answer to the vulgar fraction 21/4. If you press a b/c again, the answer is converted to a mixed number fraction (5 + 1/4). If pressed again, the display returns to the decimal fraction (5.25).



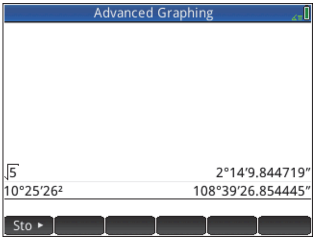
The HP Prime will approximate fraction and mixed number representations in cases where it cannot find exact ones. For example, enter $\sqrt{5}$ to see the decimal approximation: 2.236…. Press a b/c once to see $\frac{930249}{416020}$ and again to see $2+\frac{98209}{416020}$. Pressing a b/c a third time will cycle back to the original decimal representation.

Hexagesimal numbers

Any decimal result can de displayed in hexagesimal format; that is, in units subdivided into groups of 60. This includes degrees, minutes, and seconds as well as hours, minutes, and seconds. For example, enter $\frac{11}{8}$ to see the decimal result: 1.375. Now press Shift a b/c to see 1°22′30″. Press Shift a b/c again to return to the decimal representation.

The HP Prime will produce the best approximation in cases where an exact result is not possible. Enter $\sqrt{5}$ to see the decimal approximation: 2.236… Press Shift a b/c to see 2°14′9.844719″.

Note that the degree and minute entries must be positive integers. Decimals are not allowed, except in the seconds.



Note too that the HP Prime treats a value in hexgesimal format as a single entity. Hence any operation performed on a hexagesimal value is performed on the entire value. For example, if you enter 10°25′26″^{2}, the whole value is squared, not just the seconds component. The result in this case is 108°39′26.854445″.

EEX key (powers of 10)

Numbers like 5×10^4 and 3.21×10^{-7} are expressed in *scientific notation*, that is, in terms of powers of ten. This is simpler to work with than 50 000 or 0.000 000 321. To enter numbers like these, use the [EEX] functionality. This is easier than using [×] 10 [x^y].

Example: Suppose you want to calculate

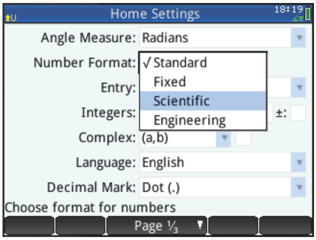
$$\frac{(4 \times 10^{-13})(6 \times 10^{23})}{3 \times 10^{-5}}$$

First select `Scientific` as the number format.

1. Open the **Home Settings** window.

   [Shift] [Settings]

2. Select `Scientific` from the **Number Format** menu.

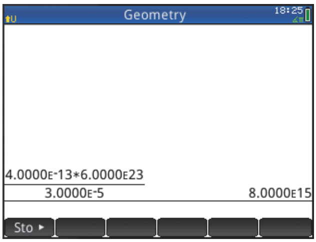


3. Return home: [Settings]

4. Enter 4 [EEX] [+/-] 13 [×] 6 [EEX] 23 [÷] 3 [EEX] [+/-] 5

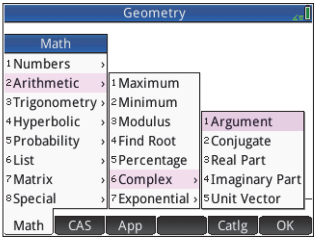
5. Press [Enter]

   The result is `8.0000E15`. This is equivalent to 8×10^{15}.



Menus

A menu offers you a choice of items. As in the case shown at the right, some menus have sub-menus and sub-sub-menus.



To select from a menu

There are two techniques for selecting an item from a menu:

- direct tapping and
- using the arrow keys to highlight the item you want and then either tapping OK or pressing Enter.

Note that the menu of buttons along the bottom of the screen can only be activated by tapping.

Shortcuts

- Press ▲ when you are at the top of the menu to immediately display the last item in the menu.
- Press ▼ when you are at the bottom of the menu to immediately display the first item in the menu.
- Press Shift ▼ to jump straight to the bottom of the menu.
- Press Shift ▲ to jump straight to the top of the menu.
- Enter the first few characters of the item's name to jump straight to that item.
- Enter the number of the item shown in the menu to jump straight to that item.

To close a menu

A menu will close automatically when you select an item from it. If you want to close a menu without selecting anything from it, use one of the following techniques:

- To close the last opened menu or sub-menu, press On.
- To close all open menus, press Esc.

Toolbox menus

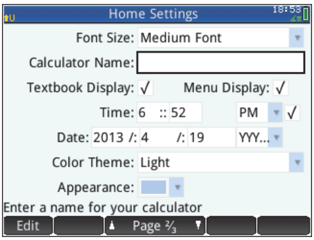
The Toolbox menus (Mem) are a collection of menus offering functions and commands useful in mathematics and programming. The **Math**, **CAS**, and **Catlg** menus offer over 400 functions and commands. The items on these menus are described in detail in chapter 20, “Functions and commands”, starting on page 283).

Input forms

An input form is a screen that provides one or more fields for you to enter data or select an option. It is another name for a dialog box.

- If a field allows you to enter data of your choice, you can select it, add your data, and tap OK. (There is no need to tap Edit first.)
- If a field allows you to choose an item from a menu, you can tap on it (the field or the label for the field), tap on it again to display the options, and tap on the item you want. (You can also choose an item from an open list by pressing the cursor keys and pressing Enter when the option you want is highlighted.)
- If a field is a toggle field—one that is either selected or not selected—tap on it to select the field and tap on it again to select the alternate option. (Alternatively, select the field and tap √.)

The illustration at the right shows an input form with all three types of field. **Calculator Name** is a free-form data-entry field, **Font Size** provides a menu of options, and **Textbook Display** is a toggle field.



Reset input form fields

To reset a field to its default value, highlight the field and press Del. To reset all fields to their default values, press Shift Esc (Clear).

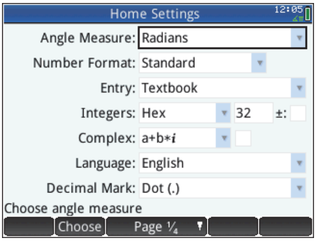
System-wide settings

System-wide settings are values that determine the appearance of windows, the format of numbers, the scale of plots, the units used by default in calculations, and much more.

There are two system-wide settings: Home settings and CAS settings. Home settings control Home view and the apps. CAS settings control how calculations are done in the computer algebra system. CAS settings are discussed in chapter 3.

Although Home settings control the apps, you can override certain Home settings once inside an app. For example, you can set the angle measure to radians in the Home settings but choose degrees as the angle measure once inside the Polar app. Degrees then remains the angle measure until you open another app that has a different angle measure.

Home settings



You use the **Home Settings** input form to specify the settings for Home view (and the default settings for the apps). Press Shift Settings (Settings) to open the **Home Settings** input form. There are four pages of settings.

Page 1

Setting	Options
Angle Measure	**Degrees**: 360 degrees in a circle. **Radians**: 2π radians in a circle. The angle mode you set is the angle setting used in both Home view and the current app. This is to ensure that trigonometric calculations done in the current app and Home view give the same result.
Number Format	The number format you set is the format used in all Home view calculations. **Standard**: Full-precision display. **Fixed**: Displays results rounded to a number of decimal places. If you choose this option, a new field appears for you to enter the number of decimal places. For example, `123.456789` becomes `123.46` in `Fixed 2` format. **Scientific:** Displays results with an exponent one digit to the left of the decimal point, and the specified number of decimal places. For example, `123.456789` becomes `1.23E2` in `Scientific 2` format. **Engineering**: Displays results 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.

Setting	Options (Continued)
Entry	**Textbook**: An expression is entered in much the same way as if you were writing it on paper (with some arguments above or below or others). In other words, your entry could be two-dimensional. **Algebraic**: An expression is entered on a single line. Your entry is always one-dimensional. **RPN**: Reverse Polish Notation. The arguments of the expression are entered first followed by the operator. The entry of an operator automatically evaluates what has already been entered.
Integers	Sets the default base for integer arithmetic: binary, octal, decimal, or hex. You can also set the number of bits per integer and whether integers are to be signed.
Complex	Choose one of two formats for displaying complex numbers: `(a,b)` or `a+b*i`.
Language	Choose the language you want for menus, input forms, and the online help.
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 (dots) as separators in these contexts.

Page 2

Setting	Options
Font Size	Choose between small, medium, and large font for general display.
Calculator Name	Enter a name for the calculator.
Textbook Display	If selected, expressions and results are displayed in textbook format (that is, much as you would see in textbooks). If not selected, expressions and results are displayed in algebraic format (that is, in one-dimensional format). For example, $\begin{bmatrix} 4 & 5 \\ 6 & 2 \end{bmatrix}$ is displayed as `[[4,5],[6,2]]` in algebraic format.
Menu Display	This setting determines whether the commands on the **Math** and **CAS** menus are presented descriptively or in common mathematical shorthand. The default is to provide the descriptive names for the functions. If you prefer the functions to be presented in mathematical shorthand, deselect this option.
Time	Set the time and choose a format: 24-hour or AM–PM format.
Date	Set the date and choose a format: `YYYY/MM/DD`, `DD/MM/YYYY`, or `MM/DD/YYYY`.
Color Theme	**Light**: black text on a light background **Dark**: white text on a dark background

Setting	Options (Continued)
Appearance	Choose a color for the shading (such as the color of the highlight).

Page 3

Page 3 of the **Home Settings** input form is for setting Exam mode. This mode enables certain functions of the calculator to be disabled for a set period, with the disabling controlled by a password. This feature will primarily be of interest to those who supervise examinations and who need to ensure that the calculator is used appropriately by students sitting an examination. It is described in detail in chapter 28, “Limiting functionality”, starting on page 519.

Page 4

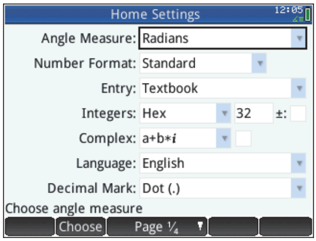
Page 4 of the **Home Settings** input form is for configuring your HP Prime to work on a wireless network. Visit www.hp.com/support for further information.

Specifying a Home setting

This example demonstrates how to change the number format from the default setting—Standard—to Scientific with two decimal places.

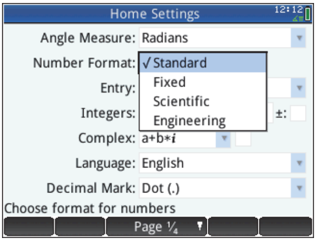
1. Press Shift Settings (Settings) to open the **Home Settings** input form.

   The **Angle Measure** field is highlighted.



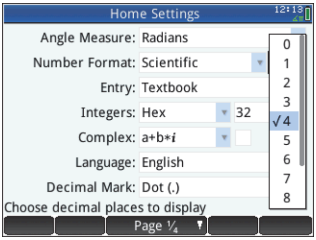
2. Tap on **Number Format** (either the field label or the field). This selects the field. (You could also have pressed ⊙ to select it.)

3. Tap on **Number Format** again. A menu of number format options appears.



4. Tap on **Scientific**. The option is chosen and the menu closes. (You can also choose an item by pressing the cursor keys and pressing Enter when the option you want is highlighted.)

5. Notice that a number appears to the right of the **Number Format** field. This is the number of decimal places currently set. To change the number to 2, tap on it twice, and then tap on 2 in the menu that appears.



6. Press Settings to return to Home view.

Mathematical calculations

The most commonly used math operations are available from the keyboard (see “Math keys” on page 20). Access to the rest of the math functions is via various menus (see “Menus” on page 25).

Note that the HP Prime represents 1×10^{-499} (as well as all numbers smaller than this) as zero. The largest number displayed is $9.99999999999 \times 10^{499}$. A greater result is displayed as this number.

Where to start

The home base for the calculator is the Home view (Settings). You can do all your non-symbolic calculations here. You can also do calculations in CAS view (which uses the computer algebra system (see chapter 3, “Computer algebra system (CAS)”, starting on page 51). In fact, you can use functions from the **CAS** menu (one of the Toolbox menus) in an expression you are entering in Home view, and use functions from the **Math** menu (another of the Toolbox menus) in an expression you are entering in CAS view.

Choosing an entry type

The first choice you need to make is the style of entry. The three types are:

- Textbook

  An expression is entered in much the same way as if you were writing it on paper (with some arguments above or below or others). In other words, your entry could be two-dimensional, as in the example above.

- Algebraic

  An expression is entered on a single line. Your entry is always one-dimensional.

- Advanced RPN (where RPN stands for *Reverse Polish Notation*). [Not available in CAS view.]

  The arguments of the depression are entered first followed by the operator. The entry of an operator automatically evaluates what has already been entered. Thus you will need to enter a two-operator expression (as in the example above) in two steps, one for each operator:

  Step 1: 5 [LN] – the natural logarithm of 5 is calculated and displayed in history.

  Step 2: [Shift] [3] [÷] – π is entered as a divisor and applied to the previous result.

  More information about RPN mode can be found in chapter 2, “Reverse Polish Notation (RPN)”, starting on page 43.

Note that on page 2 of the **Home Settings** screen, you can specify whether you want to display your calculations in Textbook format or not. This refers to the *appearance* of your calculations in the history section of both Home view and CAS view. This is a different setting to the *Entry* setting discussed above.

Entering expressions

The examples that follow assume that the entry mode is `Textbook`.

- An *expression* can contain numbers, functions, and variables.
- To enter a function, press the appropriate key, or open a Toolbox menu and select the function. You can also enter a function by using the alpha keys to spell out its name.
- When you have finished entering the expression, press Enter to evaluate it.

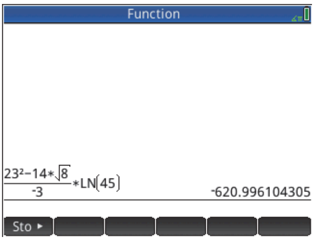
If you make a mistake while entering an expression, you can:

- delete the character to the left of the cursor by pressing Del
- delete the character to the right of the cursor by pressing Shift Del
- clear the entire entry line by pressing On or Esc.

Example

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

( ) 23 x^2 − 14 Shift x^y 8 ▶ ▶ ÷ +/− 3 ▶ LN 45 Enter



This example illustrates a number of important points to be aware of:

- the importance of delimiters (such as parentheses)
- how to enter negative numbers
- the use of implied versus explicit multiplication.

Parentheses

As the example above shows, parentheses are automatically added to enclose the arguments of functions, as in `LN()`. However, you will need to manually add parentheses—by pressing [( )]—to enclose a group of objects you want operated on as a single unit. Parentheses provide a way of avoiding arithmetic ambiguity. In the example above we wanted the entire numerator divided by –3, thus the entire numerator was enclosed in parentheses. Without the parentheses, only `14√8` would have been divided by –3.

The following examples show the use of parentheses, and the use of the cursor keys to move outside a group of objects enclosed within parentheses.

Entering ...	**Calculates ...**
[SIN] 45 [+] [Shift] [3]	$\sin(45+\pi)$
[SIN] [( )] 45 [▶] [+] [Shift] [3]	$\sin(45)+\pi$
[( )] [Shift] [x^2] 85 [▶] [×] 9	$\sqrt{85}\times 9$
[Shift] [x^2] 85 [×] 9	$\sqrt{85\times 9}$

Algebraic precedence

The HP Prime calculates according to the following order of precedence. Functions at the same level of 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 (=).

Negative numbers

It is best to press [+/-] to start a negative number or to insert a negative sign. Pressing [–] instead will, in some situations, be interpreted as an operation to subtract the next number you enter from the last result. (This is explained in "To reuse the last result" on page 37.)

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

Explicit and implied multiplication

Implied multiplication takes place when two operands appear with no operator between them. If you enter `AB`, for example, the result is `A*B`. Notice in the example on page 34 that we entered 14 [Shift] [x^y] 8 without the multiplication operator after 14. For the sake of clarity, the calculator adds the operator to the expression in history, but it is not strictly necessary when you are entering the expression. You can, though, enter the operator if you wish (as was done in the examples on page 35). The result will be the same.

Large results

If the result of a calculation is too long to fit on the display line in history, you can press [▶] to scroll the display to the right. Pressing [◀] scrolls the display to the left.

If the result is too tall to be seen in its entirety—for example, a many-rowed matrix—highlight it and then press [Show]. The result is displayed in full-screen view. You can now press [▲] and [▼] (as well as [▶] and [◀]) to bring hidden parts of the result into view. Tap [OK] to return to the previous view.

Reusing previous expressions and results

Being able to retrieve and reuse an expression provides a quick way of repeating a calculation that requires only a few minor changes to its parameters. You can retrieve and reuse any expression that is in history. You can also retrieve and reuse any result that is in history.

To retrieve an *expression* and place it on the entry line for editing, either:

- tap twice on it or its result, or
- use the cursor keys to highlight the expression and then either tap on it or tap Copy.

To retrieve a *result* and place it on the entry line, use the cursor keys to highlight it and then tap Copy. Note that double-tapping a result copies the associated expression to the entry line.

If the expression or result you want is not showing, press ▲ repeatedly to step through the entries and reveal those that are not showing. You can also swipe the screen to quickly scroll through history.

TIP Pressing Shift ▲ takes you straight to the very first entry in history, and pressing Shift ▼ takes you straight to the most recent entry.

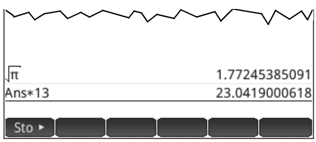
Using the clipboard

Your last four expressions are always copied to the clipboard and can easily be retrieved by pressing Shift Menu (Paste). This opens the clipboard from where you can quickly choose the one you want.

Note that expressions and not results are available from the clipboard. Note too that the last four expressions remain on the clipboard even if you have cleared history.

To reuse the last result

Press Shift + (Ans) to retrieve your last answer for use in another calculation. `Ans` appears on the entry line. This is a shorthand for your last answer and it can be part of a new expression. You could now enter other components of a calculation—such as operators, number, variables, etc.—and create a new calculation.



TIP You don't need to first select `Ans` before it can be part of a new calculation. If you press a binary operator key to begin a new calculation, `Ans` is automatically added to the entry line as the first component of the new calculation. For example, to multiply the last answer by 13, you could enter Shift + × 13 Enter. But the first two keystrokes are unnecessary. All you need to enter is × 13 Enter.

The variable `Ans` is always stored with full precision whereas the results in history will only have the precision determined by the current Number Format setting (see page 28). In other words, when you retrieve the number assigned to `Ans`, you get the result to its full precision; but when you retrieve a number from history, you get exactly what was displayed.

You can repeat the previous calculation simply by pressing Enter. This can be useful if the previous calculation involved `Ans`. For example, suppose you want to calculate the *n*th root of 2 when *n* is 2, 4, 8, 16, 32, and so on.

1. Calculate the square root of 2.

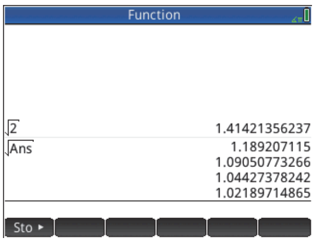
   Shift x^2 2 Enter

2. Now enter √`Ans`.

   Shift x^2 Shift + Enter

   This calculates the fourth root of 2.

3. Press Enter repeatedly. Each time you press, the root is twice the previous root. The last answer shown in the illustration at the right is $\sqrt[32]{2}$.



To reuse an expression or result from the CAS

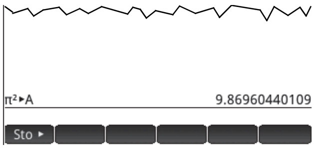
When your are working in Home view, you can retrieve an expression or result from the CAS by tapping Menu Paste and selecting `Get from CAS`. The CAS opens. Press ▲ or ▼ until the item you want to retrieve is highlighted and press Enter. The highlighted item is copied to the cursor point in Home view.

Storing a value in a variable

You can store a value in a variable (that is, assign a value to a variable). Then when you want to use that value in a calculation, you can refer to it by the variable's name. You can create your own variables, or you can take advantage of the built-in variables in Home view (named *A* to *Z* and θ) and in the CAS (named *a* to *z,* and a few others). CAS variables can be used in calculations in Home view, and Home variables can be used in calculations in the CAS. There are also built-in app variables and geometry variables. These can also be used in calculations.

Example: To assign π^2 to to the variable *A*:

Shift 3 x^2 Sto ▸ ALPHA Vars Enter



Your stored value appears as shown at the right. If you then wanted to multiply your stored value by 5, you could enter: ALPHA Vars × 5 Enter.

You can also create your own variables in Home view. For example, suppose you wanted to create a variable called `ME` and assign π^2 to it. You would enter:

Shift 3 x^2 Sto ▸ ALPHA +/− ALPHA a b/c Enter

A message appears asking if you want to create a variable called ME. Tap OK or press Enter to confirm your intention. You can now use that variable in subsequent calculations: `ME*3` will yield 303, for example.

You can also create variables in CAS view in the same way. However, the built-in CAS variables must be entered in lowercase. However, the variables you create yourself can be uppercase or lowercase.

See chapter 21, "Variables", starting on page 373 for more information.

As well as built-in Home and CAS variables, and the variables you create yourself, each app has variables that you can access and use in calculations. See “App functions and variables” on page 99 for more information.

Complex numbers

You can perform arithmetic operations using complex numbers. Complex numbers can be enterded in any one of the following forms, where *x* is the real part, *y* is the imaginary part, and i is the imaginary constant, $\sqrt{-1}$:

- (x, y)
- $x + iy$ or
- $x - iy$

To enter i:

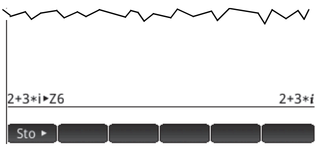
- press ALPHA Shift TAN

  or

- press Shift 2.

There are 10 built-in variables available for storing complex numbers. These are labeled `Z0` to `Z9`. You can also assign a complex number to a variable you create yourself.

To store a complex number in a variable, enter the complex number, press Sto ▸, enter the variable that you want to assign the complex number to, and then press Enter. For example, to store `2+3i` in variable `Z6`:

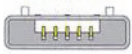


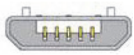
( ) 2 , 3 ▶ Sto ▸ ALPHA 2 6 Enter

Sharing data

As well as giving you access to many types of mathematical calculations, the HP Prime enables you to create various objects that can be saved and used over and over again. For example, you can create apps, lists, matrices, programs, and notes. You can also send these objects to other HP Primes. Whenever you encounter a screen with Send as a menu item, you can select an item on that screen to send it to another HP Prime.

You used the supplied USB cable to send objects from one HP Prime to another. Note that the connectors on the ends of the USB cable are slightly different. The micro-A connector has a rectangular end and the micro-B connector has a trapezoidal end. To share objects with another HP Prime, the micro-A connector must be inserted into the USB port on the *sending* calculator, with the micro-B connector inserted into the USB port on the *receiving* calculator.


Micro-A: sender


Micro-B: receiver

General procedure

The general procedure for sharing objects is as follows:

1. Navigate to the screen that lists the object you want to send.

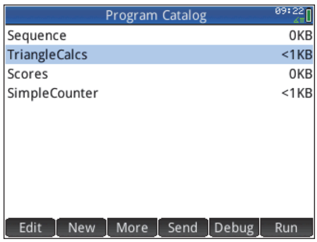
   This will be the Application Library for apps, the List Catalog for lists, the Matrix Catalog for matrices, the Program Catalog for programs, and the Notes Catalog for notes.

2. Connect the USB cable between the two calculators.

   The micro-A connector—with the rectangular end—must be inserted into the USB port on the *sending* calculator.

3. On the sending calculator, highlight the object you want to send and tap Send.

   In the illustration at the right, a program named `TriangleCalcs` has been selected in the Program Catalog



and will be sent to the connected calculator when Send is tapped.

4. What happens on the receiving calc?

Online Help

Press Help to open the online help. The help initially provided is context-sensitive, that is, it is always about the current view and its menu items.

For example, to get help on the Function app, press Apps, select Function, and press Help.

From within the help system you can navigate to other help topics. You can find help on any key, view, or command. And tapping Tree displays a hierarchical directory of all the help topics.

2

Reverse Polish Notation (RPN)

The HP Prime provides you with three ways of entering objects in Home view:

- Textbook

  An expression is entered in much the same way was if you were writing it on paper (with some arguments above or below or others). In other words, your entry could be two-dimensional, as in the following example:

- Algebraic

  An expression is entered on a single line. Your entry is always one-dimensional. The same calculation as above would appear like this is algebraic entry mode:

- Advanced RPN (where RPN stands for *Reverse Polish Notation*).

  The arguments of the expression are entered first followed by the operator. The entry of an operator automatically evaluates what has already been entered. Thus you will need to enter a two-operator expression (as in the example above) in two steps, one for each operator:

  Step 1: 5 [LN] – the natural logarithm of 5 is calculated and displayed in history.

  Step 2: [Shift] [3] [÷] – π is entered as a divisor and applied to the previous result.

You choose your preferred entry method from page 1 of the **Home Settings** screen ([Shift] [Settings]). See "System-wide settings", starting on page 27 for instructions on how to choose settings.

RPN is available in Home view, but not in CAS view.

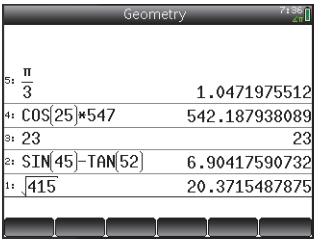
The same entry-line editing tools are available in RPN mode as in algebraic and textbook mode:

- Press Del to delete the character to the left of the cursor.
- Press Shift Del to delete the character to the right of the cursor.
- Press Esc Clear to clear the entire entry line.
- Press Shift Esc Clear to clear the entire entry line.

History in RPN mode

The results of your calculations are kept in history. This history is displayed above the entry line (and by scrolling up to calculations that are no longer immediately visible). The calculator offers three histories: one for the CAS view and two for Home view. CAS history is discussed in chapter 3. The two histories in Home view are:

- non-RPN: visible if you have chosen algebraic or textbook as your preferred entry technique
- RPN: visible only if you have chosen RPN as your preferred entry technique. The RPN history is also called the *stack*. As shown in the illustration below, each entry in the stack is given a number. This is the stack level number.



As more calculations are added, an entry's stack level number increases.

If you switch from RPN to algebraic or textbook entry, your history is not lost. It is just not visible. If you switch back to RPN, your RPN history is redisplayed. Likewise, if you switch to RPN, your non-RPN history is not lost.

When you are not in RPN mode, your history is ordered chronologically: oldest calculations at the top, most recent at the bottom. In RPN mode, your history is ordered chronologically by default, but you can change the order of the items in history. (This is explained in “Manipulating the stack” on page 47.)

Re-using results

There ate two ways to re-use a result in history. Method 1 deselects the copied result after copying; method 2 keeps the copied item selected.

Method 1

1. Select the result to be copied. You can do this by pressing ▲ or ▼ until the result is highlighted, or by tapping on it.
2. Press Enter. The result is copied to the entry line and is deselected.

Method 2

1. Select the result to be copied. You can do this by pressing ▲ or ▼ until the result is highlighted, or by tapping on it.
2. Tap Stack and select `ECHO`. The result is copied to the entry line and remains selected.

Although it might appear that only the result of the previous calculation is copied to the entry line, the calculation that produced that result is copied as well and becomes part of the new calculation. This is so regardless of the method chosen to copy the item.

Note that while you can copy an item from the CAS history to use in a Home calculation (and copy an item from the Home history to use in a CAS calculation), you cannot copy items from or to the RPN history. You can, however, use CAS commands and functions when working in RPN mode.

Re-using calculations

As well as re-using results (discussed in the previous section), you can copy an entire calculation. The copy is placed on stack level 1 and thus can easily be incorporated in your next calculation. You can also move an item to stack level 1. These changes to the stack are explained in “Manipulating the stack” on page 47.

Sample calculations

The general philosophy behind RPN is that arguments are placed before operators. The arguments can be on the entry line (each separated by a space) or they can be in history. For example, to multiply π by 3, you could enter:

Shift π 3 # ␣ 3

on the entry line and then enter the operator (×). Thus your entry line would look like this before entering the operator:

```
π 3
```

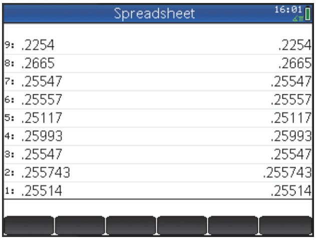
However, you could also have entered the arguments separately and then, with a blank entry line, entered the operator (×). Your history would look like this before entering the operator:

```
2: π                3.14159265359
1: 3                            3
```

If there are no entries in history and you enter an operator or function, an error message appears. An error message will also appear if there is an entry on a stack level that an operator needs but it is not an appropriate argument for that operator. For example, pressing COS ACOS H when there is a string on level 1 displays an error message.

An operator or function will work only on the minimum number of arguments necessary to produce a result. Thus if you enter on the entry line `2 4 6 8` and press ×, stack level 1 shows `48`. Multiplication needs only two arguments, so the two arguments last entered are the ones that get multiplied. The entries `2` and `4` are not ignored: `2` is placed on stack level 3 and `4` on stack level 2.

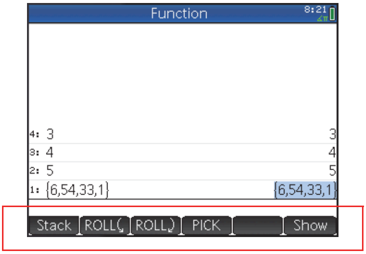
Where a function can accept a variable number of arguments, you need to specify how many arguments you want it to include in its operation. You do this by specifying the number in parentheses straight after the function name. You then press Enter ≈ to evaluate the function. For example, suppose your stack looks like this:



Suppose further that you want to determine the minimum of just the numbers on stack levels 1, 2, and 3. You choose the `MIN` function from the MATH menu and complete the entry as `MIN(3)`. When you press Enter, the minimum of just the last three items on the stack is displayed.

Manipulating the stack

A number of stack-manipulation options are available. Most appear as menu items across the bottom the screen. To see these items, you must first select an item in history:



PICK

Copies the selected item to stack level 1. The item below the one that is copied is then highlighted. Thus if you tapped PICK four times, four consecutive items will be moved to the bottom four stack levels (levels 1–4).

ROLL

There are two roll commads:

- Tap ROLL to move the selected item to stack level 1. This is similar to PICK, but PICK duplicates the item, with the duplicate being placed on stack level1. However, ROLL doesn't duplicate an item. It simply moves it.
- Tap ROLL to move the item on stack level 1 to the currently highlighted level

Swap

You can swap the position of the objects on stack level 1 with those on stack level 2. Just press [, Eval]. The level of other objects remains unchanged. Note that the entry line must not be active at the time, otherwise a comma will be entered.

Stack

Tapping Stack displays further stack-manipulation tools.

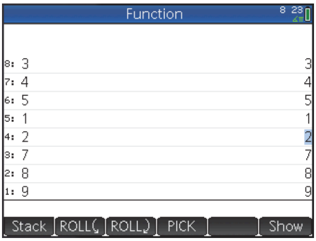
DROPN Deletes all items in the stack from the highlighted item down to and including the item on stack level 1. Items above the highlighted item drop down to fill the levels of the deleted items.

If you just want to delete a single item from the stack, see "Delete an item" below.

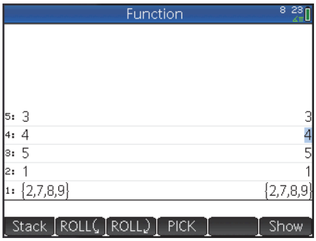
DUPN Duplicates all items between (and including) the highlighted item and the item on stack level 1. If, for example, you have selected the item on stack level 3, selecting `DUPN` duplicates it and the two items below it, places them on stack levels 1 to 3, and moves the items that were duplicated up to stack levels 4 to 6.

Echo Places a copy of the selected result on the entry line and leaves the source result highlighted. [Not working]

→LIST Creates a list of results, with the highlighted result the first element in the list and the item on stack level 1 the last.



Before



After

Show an item

To show a result in full-screen textbook format, tap Show.

Tap OK to return to the history.

Delete an item

To delete an item from the stack:

1. Select it. You can do this by pressing ▲ or ▼ until the item is highlighted, or by tapping on it.

2. Press Del.

Delete all items

To delete all items, thereby clearing the history, press Shift Esc Clear.

3

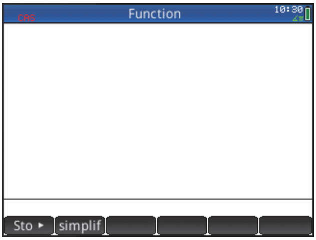
Computer algebra system (CAS)

A computer algebra system (CAS) enables you to perform symbolic calculations. By default, CAS works in exact mode, giving you infinite precision. On the other hand, non-CAS calculations, such as those performed in HOME view or by an aplet, are numerical calculations and are often approximations limited by the precision of the calculator (to 10^{-12} in the case of the HP Prime). For example, $\frac{1}{3}+\frac{2}{7}$ yields the approximate answer .619047619047 in Home view (with Standard numerical format), but yields the exact answer $\frac{13}{21}$ in the CAS.

The CAS offers many hundreds of functions, covering algebra, calculus, equation solving, polynomials, and more. You select a function from the **CAS** menu, one of the Toolbox menus discussed in chapter 20, “Functions and commands”, beginning on page 283. Consult that chapter for a description of all the CAS functions and commands.

CAS view

CAS calculations are done in CAS view. CAS view is almost identical to Home view. A history of calculations is built and you can select and copy previous calculations just as you can in Home view, as well as store objects in variables.



To open CAS view, press CAS Settings. **CAS** appears in red at the left of the title bar to indicate that you are in CAS view rather than Home view.

The menu buttons in CAS view are:

- Sto ▸ : assigns an object to a variable

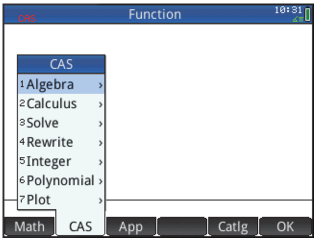
- simplif: applies common simplification rules to reduce an expression to its simplest form. For example, simplify($e^{a + \mathrm{LN}(b*e^{c})}$) yields b*EXP(a)*EXP(c).
- Copy: copies a selected entry ion history to the entry line
- Show: displays the selected entry in full-screen mode, with horizontal land vertical scrolling enabled. The entry is also presented in textbook format.

CAS calculations

With one exception, you perform calculations in CAS view just as you do in Home view. (The exception is that there is no RPN entry mode in CAS view, just algebraic and textbook modes). All the keys work in the same way in CAS view as Home view. The primary difference is that the default display of answers is symbolic rather than numeric.

You can also use the template key (Units) to help you insert the framework for common calculations (and for vectors and matrices). This is explained in detail in "Math template" on page 21.

The most commonly used CAS functions are available from the CAS menu, one of the Toolbox menus. To display the menu, press Mem. (If the CAS menu is not open by default, tap CAS.) Other CAS commands are available from the CATLG menu (another of the Toolbox menus).



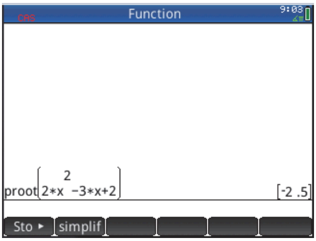
To choose a function, select a category and then a command.

Example 1

To find the roots of $2x^2 + 3x - 2$:

1. With the CAS menu open, select **Polynomial** and then **Find Roots**.

The function `proot()` appears on the entry line.



2. Between the parentheses, enter:

   2 [ALPHA] [Shift] [×] [x²] [+]
   3 [ALPHA] [Shift] [×] [−] 2

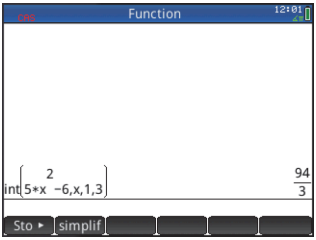
3. Press [Enter].

Example 2

To find the area under the graph of $5x^2 - 6$ between $x = 1$ and $x = 3$:

1. With the CAS menu open, select **Calculus** and then **Integrate**.

   The function `int()` appears on the entry line.



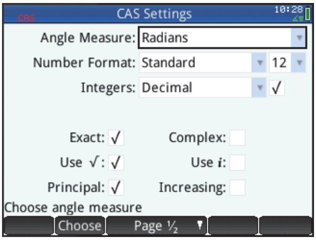
2. Between the parentheses, enter:

   5 [ALPHA] [Shift] [×] [x²] [−]
   6 [,] [ALPHA] [Shift] [×] [,]
   1 [,] 3

3. Press [Enter].

Settings

Various settings allow you to configure how the CAS works. To display the settings, press [Shift] [CAS Settings]. The modes are spread across two pages.



Page 1

Setting	Purpose
Angle Measure	Select the units for angle measurements: `Radians` or `Degrees`.

Setting	Purpose (Cont.)
Number Format (first drop-down list)	Select the number format for displayed solutions: `Standard` or `Scientific` or `Engineering`
Number Format (second drop-down list)	Select the number of digits to display in approximate mode (mantissa + exponent).
Integers (drop-down list)	Select the integer base: `Decimal` (base 10) `Hex` (base 16) `Octal` (base 8)
Integers (check box)	If checked, any real number equivalent to an integer in a non-CAS environment will be converted to an integer in the CAS. (Real numbers not equivalent to integers are treated as real numbers in CAS whether or not this option is selected.)
Exact	If checked, the calculator is in exact mode and solutions will be symbolic. If not checked, the calculator is in approximate mode and solutions will be approximate. For example, 26 [÷] 5 yields $\frac{26}{5}$ in exact mode and 5.2 in approximate mode.
Complex	Select this to allow complex results in variables.
Use √	If checked, second order polynomials are factorized in complex mode or in real mode if the discriminant is positive.

Setting	Purpose (Cont.)
Use *i*	If checked, the calculator is in complex mode and complex solutions will be displayed when they exist. If not checked, the calculator is in real mode and only real solutions will be displayed. For example, factors(x^4–1) yields (–1+x),(1+x),(i+x),(–i+x) in complex mode and (–1+x),(1+x),(1+x^2) in real mode.
Principal	If checked, the principal solutions to trigonometric functions will be displayed. If not checked, the general solutions to trigonometric functions will be displayed.
Increasing	If checked, polynomials will be displayed with increasing powers (for example, $-4+x+3x^2+x^3$). If not checked, polynomials will be displayed with decreasing powers (for example, x^3+3x^2+x-4).

Page 2

Setting	Purpose
Recursive Evaluation	Specify the maximum number of embedded variables allowed in an interactive evaluation. See also `Recursive Replacement` below.
Recursive Replacement	Specify the maximum number of embedded variables allowed in a single evaluation in a program. See also `Recursive Evaluation` above.
Recursive Function	Specify the maximum number of embedded function calls allowed.

Setting	Purpose (Cont.)
Epsilon	Any number smaller than the value specified for epsilon will be shown as zero.
Probability	Specify the maximum probability of an answer being wrong for non-deterministic algorithms. Set this to zero for deterministic algorithms.
Newton	Specify the maximum number of iterations when using the Newtonian method to find the roots of a quadratic.

Setting the form of menu items

One setting that affects the CAS is made outside the **CAS Settings** screen. This setting determines whether the commands on the CAS menu are presented descriptively or by their command name. Here are some examples of identical functions that are presently differently depending on what presentation mode you select:

Descriptive name	Command name
Factors List	ifactors
Complex Zeros	cZeros
Groebner Basis	gbasis
Factor by Degree	factor_xn
Find Roots	proot

The default menu presentation mode is to provide the descriptive names for the CAS functions. If you prefer the functions to be presented by their command name, deselect the **Menu Display** option on the second page of the **Home Settings** screen (see “Home settings” on page 27).

To use an expression or result from Home view

When your are working in CAS, you can retrieve an expression or result from Home view by tapping Menu Paste and selecting `Get from Home`. Home view opens. Press ▲ or ▼ until the item you want to retrieve is highlighted and press Enter.

The highlighted item is copied to the cursor point in CAS.

To use a Home variable in CAS

You can access Home variables from within the CAS. Home variables are assigned uppercase letters; CAS variables are assigned lowercase letters. Thus SIN(x) and SIN(X) will yield different results.

To use a Home variable in the CAS, simply include its name in a calculation. For example, suppose in Home view you have assigned variable *Q* to 100. Suppose too that you have assigned variable *q* to 1000 in the CAS. If you are in the CAS and enter 5**q*, the result is 5000. If had entered 5**Q* instead, the result would be 500.

In a similar way, CAS variables can be used in calculations in Home view. Thus you can enter 5**q* in Home view and get 500, even though q is a CAS variable.

4

An introduction to HP apps

Much of the functionality of the HP Prime is provided in packages called HP apps. The HP Prime comes with 18 HP apps: 10 dedicated to mathematical topics or tasks, three specialized Solvers, three function Explorers, a spreadsheet, and an app for recording data streamed to the calculator from an external sensing device. You launch an app by first pressing Apps Info (which displays the **Application Library** screen) and tapping on the icon for the app you want.

What each app enables you to do is outlined in the following, where the apps are listed in alphabetical order.

App name	Use this app to:
Advanced Graphing	Explore the graphs of symbolic open sentences in *x* and y. Example: $x^2 + y^2 = 64$
Data Streamer	Collect real-world data from scientific sensors and export it to a statistics app for analysis.
Finance	Solve time-value-of-money (TVM) problems and amortization problems.
Function	Explore real-valued, rectangular functions of *y* in terms of *x*. Example: $y = 2x^2 + 3x + 5$
Geometry	Explore geometric constructions and perform geometric calculations.
Inference	Explore confidence intervals and hypothesis tests based on the Normal and Student's-t distributions.
Linear Explorer	Explore the properties of linear equations and test your knowledge.

App name	Use this app to: (Cont.)
Linear Solver	Find solutions to sets of two or three linear equations.
Parametric	Explore parametric functions of *x* and *y* in terms of *t*. Example: $x = \cos(t)$ and $y = \sin(t)$.
Polar	Explore polar functions of *r* in terms of an angle θ. Example: $r = 2\cos(4\theta)$
Quadratics Explorer	Explore the properties of quadratic equations and test your knowledge.
Sequence	Explore sequence functions, where *U* is defined in terms of *n*, or in terms of previous terms in the same or another sequence, such as U_{n-1} and U_{n-2}. Example: $U_1 = 0$, $U_2 = 1$ and $U_n = U_{n-2} + U_{n-1}$
Solve	Explore equations in one or more real-valued variables, and systems of equations. Example: $x + 1 = x^2 - x - 2$
Spreadsheet	To solve problems or represent data best suited to a spreadsheet.
Statistics 1Var	Calculate one-variable statistical data (*x*)
Statistics 2Var	Calculate two-variable statistical data (*x* and *y*)
Triangle Solver	Find the unknown values for the lengths and angles of triangles.
Trig Explorer	Explore the properties of sinusoidal equations and test your knowledge.

As you use an app to explore a lesson or solve a problem, you add data and definitions in one or more of the app's views. All this information is automatically saved in the app. You can come back to the app at any time and all the information is still there. You can also save a version of the app with a name you give it and then use the original app for another problem or purpose. See "Creating an app" on page 97 for more information about customizing and saving apps.

With one exception, all the apps mentioned above are described in detail in this user guide. The exception is the DataStreamer app. A brief introduction to this app is given in the HP Prime *Quick Start Guide*. Full details can be found in the *HP StreamSmart 410 User Guide* (available on the product CD).

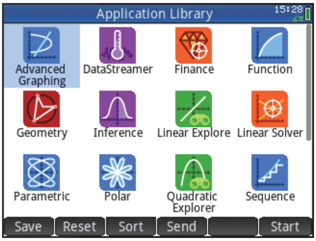
Application Library

Apps are stored in the Application Library, displayed by pressing Apps Info.

To open an app

1. Open the Application Library.
2. Find the app's icon and tap on it.

   You can also use the cursor keys to scroll to the app and, when it is highlighted, either tap Start or press Enter.



To reset an app

You can leave an app at any time and all the data and settings in it are retained. When you return to the app, you can continue as you left off.

However, if you don't want to use the previous data and settings, you can return the app to its default state, that is, the state it was in when you opened it for the first time. To do this:

1. Open the Application Library.
2. Use the cursor keys to highlight the app.
3. Tap Reset.
4. Tap OK to confirm your intention.

You can also reset an app from within the app. From the main view of the app—which is usually, but not always, the Symbolic view—press Shift Esc Clear and tap OK to confirm your intention.

To sort apps

By default, the apps in the Application Library are sorted chronologically, with the most recently used app shown first. You can change the sort order to:

- Alphabetically

The app icons are sorted alphabetically by name, and in ascending order: A to Z.

- Fixed

  Apps are displayed in their default order: Function, Advanced Graphing, Geometry … Polar, and Sequence. Customized apps are placed at the end, after all the built-in apps. They appear in chronological order: oldest to most recent.

To change the sort order:

1. Open the Application Library.
2. Tap Sort.
3. From the **Sort Apps** list, choose the option you want.

To delete an app

The apps that come with the HP Prime are built-in and cannot be deleted, but you can delete an app you have created. To delete an app:

1. Open the Application Library.
2. Use the cursor keys to highlight the app.
3. Tap Delete.
4. Tap OK to confirm your intention.

Other options

The other options available in the Application Library are:

- Save

  Enables you to save a copy of an app under a new name. See “Creating an app” on page 97.

- Send

  Enables you to send an app to another HP Prime. See “Sharing data” on page 40.

App views

Most apps have three major views: Symbolic, Plot, and Numeric. These views are based on the symbolic, graphic, and numeric representations of mathematical objects. They are accessed through the Symb Setup, Plot Setup, and Num Setup keys near the top left of the keyboard. Typically these views enable you to define a mathematical object—such as an expression or an open sentence—plot it, and see the values generated by it.

Each of these views has an accompanying setup view, a view that enables you to configure the appearance of the data in the accompanying major view. These views are called Symbolic Setup, Plot Setup, and Numeric Setup. They are accessed by pressing Esc Symb, Esc Plot, and Esc Num.

Not all apps have all the six views outlined above. The scope and complexity of each app determines its particular set of views. For example, the Spreadsheet app has no Plot view or Plot Setup view, and the Quadratic Explorer has only a Plot view. What views are available in each app is outlined in the next six sections.

Note that the DataStreamer app is not covered in this chapter. See *HP StreamSmart 410 User Guide* for information about this app.

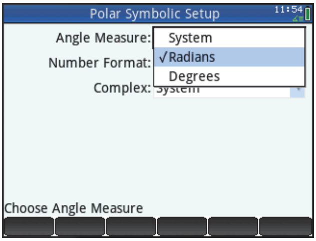
Symbolic view

The table below outlines what is done in the Symbolic view of each app.

App	Use the Symbolic view to:
Advanced Graphing	Specify up to 10 open sentences.
Finance	Not used
Function	Specify up to 10 real-valued, rectangular functions of *y* in terms of *x*.
Geometry	View the symbolic definition of geometric constructions.
Inference	Choose to conduct a hypothesis test or test a confidence level, and select a type of test.
Linear Explorer	Not used
Linear Solver	Not used
Parametric	Specify up to 10 parametric functions of *x* and *y* in terms of *t*.
Polar	Specify up to 10 polar functions of *r* in terms of an angle θ.

App	Use the Symbolic view to: (Cont.)
Quadratics Explorer	Not used
Sequence	Specify up to 10 sequence functions.
Solve	Specify up to 10 equations.
Spreadsheet	Not used
Statistics 1Var	Specify up to 5 univariate analyses.
Statistics 2Var	Specify up to 5 multivariate analyses.
Triangle Solver	Not used
Trig Explorer	Not used

Symbolic Setup view



The Symbolic Setup view is the same for each app. It enables you to override the system-wide settings for angle measure, number format, and complex-number entry. The override applies only to the current app.

To change the settings for all apps, see "System-wide settings" on page 27.

Plot view

The table below outlines what is done in the Plot view of each app.

App	Use the Polar view to:
Advanced Graphing	Plot and explore the open sentences selected in Symbolic view.
Finance	Display an amortization graph.
Function	Plot and explore the functions selected in Symbolic view.
Geometry	Create and manipulate geometric constructions.

App	Use the Polar view to: (Cont.)
Inference	View a plot of the test results.
Linear Explorer	Explore linear equations and test your knowledge of them.
Linear Solver	Not used
Parametric	Plot and explore the functions selected in Symbolic view.
Polar	Plot and explore the functions selected in Symbolic view.
Quadratics Explorer	Explore quadratic equations and test your knowledge of them.
Sequence	Plot and explore the sequences selected in Symbolic view.
Solve	Plot and explore a single function selected in Symbolic view.
Spreadsheet	Not used
Statistics 1Var	Plot and explore the analyses selected in Symbolic view.
Statistics 2Var	Plot and explore the analyses selected in Symbolic view.
Triangle Solver	Not used
Trig Explorer	Explore sinusoidal equations and test your knowledge of them.

Plot Setup view

The table below outlines what is done in the Plot Setup view of each app.

App	Use the Polar view to:
Advanced Graphing	Modify the appearance of plots and the plot environment.
Finance	Not used

App	Use the Polar view to: (Cont.)
Function	Modify the appearance of plots and the plot environment.
Geometry	Modify the appearance of the drawing environment.
Inference	Not used
Linear Explorer	Not used
Linear Solver	Not used
Parametric	Modify the appearance of plots and the plot environment.
Polar	Modify the appearance of plots and the plot environment.
Quadratics Explorer	Not used
Sequence	Modify the appearance of plots and the plot environment.
Solve	Modify the appearance of plots and the plot environment.
Spreadsheet	Not used
Statistics 1Var	Modify the appearance of plots and the plot environment.
Statistics 2Var	Modify the appearance of plots and the plot environment.
Triangle Solver	Not used
Trig Explorer	Not used

Numeric view

The table below outlines what is done in the Numeric view of each app.

App	Use the Numeric view to:
Advanced Graphing	View a table of numbers generated by the open sentences selected in Symbolic view.

App	Use the Numeric view to: (Cont.)
Finance	Enter values for time-value-of-money calculations.
Function	View a table of numbers generated by the functions selected in Symbolic view.
Geometry	Perform calculations on the geometric objects drawn in Plot view.
Inference	Specify the statistics needed to perform the test selected in Symbolic view.
Linear Explorer	Not used
Linear Solver	Specify the coefficients of the linear equations to be solved.
Parametric	View a table of numbers generated by the functions selected in Symbolic view.
Polar	View a table of numbers generated by the functions selected in Symbolic view.
Quadratics Explorer	Not used
Sequence	View a table of numbers generated by the sequences selected in Symbolic view.
Solve	Enter the known values and solve for the unknown value.
Spreadsheet	Enter numbers, text, formulas, etc. The Numeric view is the primary view for this app.
Statistics 1Var	Enter data for analysis.
Statistics 2Var	Enter data for analysis.
Triangle Solver	Enter known data about a triangle and solve for the unknown data.
Trig Explorer	Not used

Numeric Setup view

The table below outlines what is done in the Numeric Setup view of each app.

App	Use the Numeric Setup view to:
Advanced Graphing	Specify the numbers to be calculated according to the open sentences specified in Symbolic view, and set the zoom factor.
Finance	Not used.
Function	Specify the numbers to be calculated according to the functions specified in Symbolic view, and set the zoom factor.
Geometry	Not used
Inference	Not used
Linear Explorer	Not used
Linear Solver	Not used
Parametric	Specify the numbers to be calculated according to the functions specified in Symbolic view, and set the zoom factor.
Polar	Specify the numbers to be calculated according to the functions specified in Symbolic view, and set the zoom factor.
Quadratics Explorer	Not used.
Sequence	Specify the numbers to be calculated according to the sequences specified in Symbolic view, and set the zoom factor.
Solve	Not used
Spreadsheet	Format cells, rows, columns, or the entire spreadsheet.
Statistics 1Var	Not used
Statistics 2Var	Not used
Triangle Solver	Not used

App	Use the Numeric Setup view to: (Cont.)
Trig Explorer	Not used

Quick example

The following example uses all six app views and should give you an idea of the typical workflow involved in working with an app. The Polar app is used as the sample app.

Open the app

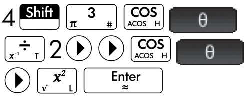
1. Open the Application Library by pressing Apps.
2. Tap once on the icon of the Polar app.

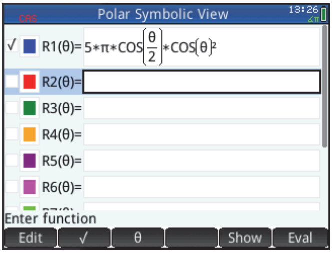
   The Polar app opens in Symbolic View.

Symbolic view

The Symbolic view of the Polar app is where you define or specify the polar equation you want to plot and explore. In this example we will plot and explore the equation $r = 4\pi\cos(\theta/2)\cos(\theta)^2$.

3. Define the equation $r = 4\pi\cos(\theta/2)\cos(\theta)^2$ by entering:

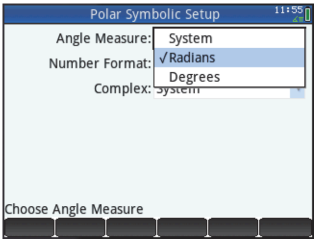




This equation will draw symmetrical petals provided that the angle measure is set to radians. The angle measure for this app is set in the Symbolic Setup view.

Symbolic Setup view

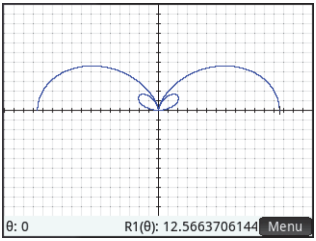
4. Press Shift Symb.
5. Select `Radians` from the **Angle Measure** menu.



Plot view

6. Press Plot ↳Setup.

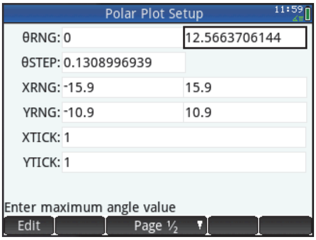
   A graph of the equation is plotted. However, as the illustration at the right shows, only a part of the petals is visible. To see the rest you will need to change the plot setup parameters.



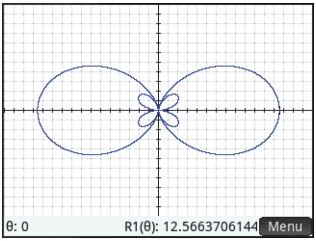
Plot Setup View

7. Press Shift Plot ↳Setup.
8. Set the second θ**RNG** field to 4π by entering:

   ▶ 4 Shift π 3 # (π) OK



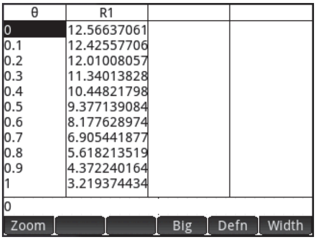
9. Press Plot ↳Setup to return to Plot view and see the complete plot.



Numeric View

The values generated by the equation can be seen in Numeric view.

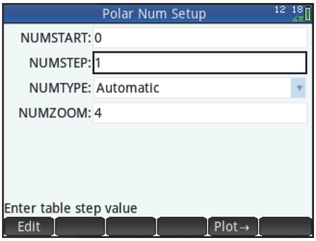
10. Press Num ↳Setup.



Suppose you want to see just whole numbers for θ; in other words, you want the increment between consecutive values in the θ column to be 1. You set this up in the Numeric Setup view.

Numeric Setup View

11. Press Shift Num.
12. Change the **NUMSTEP** field to 1.
13. Press Num to return to Numeric view.



You will see that the θ column now contains consecutive integers starting from zero, and the corresponding values calculated by the equation specified in Symbolic view are listed in the R1 column.

Common operations in Symbolic view

[Scope: Advanced Graphing, Function, Parametric, Polar, Sequence, Solve. See dedicated app chapters for information about the other apps.]

Symbolic view functionality that is common to many apps is described in detail in this section. Functionality that is available only in a particular app is described in the chapter dedicated to that app.

Symbolic view is typically used to define a function or open sentence that you want to explore (by plotting and/or evaluating). In this section, the term *definition* will be used to cover both functions and open sentences.

Press Symb to open Symbolic view.

Add a definition

With the exception of the Parametric app, there are 10 fields for entering definitions. In the Parametric app there are 20 fields, two for each paired definition.

1. Highlight an empty field you want to use, either by tapping on it or scrolling to it.
2. Enter your definition.

   If you need help, see "Definitional building blocks" on page 72.
3. Tap OK or press Enter when you have finished.

Your new definition is added to the list of definitions.

Note that variables used in definitions must be in uppercase. A variable entered in lowercase will cause an error message to appear.

Modify a definition

1. Highlight the definition you want to modify, either by tapping on it or scrolling to it.
2. Tap Edit.

   The definition is copied to the entry line.
3. Modify the definition.
4. Tap OK or press Enter when you have finished.

Definitional building blocks

The components that make up a symbolic definition can come from a number of sources.

- From the keyboard

  You can enter components directly from the keyboard. To enter $2X^2 - 3$, just press 2 ALPHA X x^2 − 3.
- From user variables

  If, for example, you have created a variable called `COST`, you could incorporate that into a definition either by typing it or choosing it from the **User** menu (one of the sub-menus of the Variables menu). Thus you could have a definition that reads `F1(X)=X`^{2}`+COST`.

  To select a user variable, press Vars, tap User, select **User Variables**, and then select the variable of interest.
- From Home variables

  Some Home variables can be incorporated into a symbolic definition. To access a Home variable, press Vars, tap Home, select a category of variable, and select the variable of interest. Thus you could have a definition that reads `F1(X)=X`^{2}`+Q`. (`Q` is on the **Real** sub-menu of the **Home** menu.)

  Home variables are discussed in detail in chapter 28, "Troubleshooting", beginning on page 507.
- From app variables

All settings, definitions, and results, for all apps, are stored as variables. Many of these variables can be incorporated into a symbolic definition. To access app variables, press Vars, tap App, select the app, select the category of variable, and then select the variable of interest. You could, for instance, have a definition that reads `F2(X)=X²+X-Root`. The value of the last root calculated in the Function app is substituted for `Root` when this definition is evaluated.

App variables are discussed in detail in chapter 28, "Troubleshooting", beginning on page 507.

- From math functions

  Some of the functions on the **Math** menu can be incorporated into a definition. The **Math** menu is one of the Toolbox menus ( ). The following definition combines a math function (`Size`) with a Home variable (`L1`): `F4(X)=X²-SIZE(L1)`. It is equivalent to $x^2 - n$ where n is the number of elements in the list named `L1`. (`Size` is an option on the **List** menu, which is a sub-menu of the **Math** menu.)

- From CAS functions

  Some of the functions on the **CAS** menu can be incorporated into a definition. The **CAS** menu is one of the Toolbox menus ( ). The following definition incorporates the CAS function `irem`: `F5(X)=X²+CAS.irem(45,7)`. (`irem` is entered by choosing `Remainder`, an option on the **Division** menu, which is a sub-menu of the **Integer** menu. Note that any CAS command or function selected to operate outside the CAS is given the `CAS.` prefix.)

- From app functions

  Some of the functions on the **App** menu can be incorporated into a definition. The **App** menu is one of the Toolbox menus ( ). The following definition incorporates the app function `PredY`:

  `F9(X)=X²+Statistics_2Var.PredY(6).`

- From the **Catlg** menu

  Some of the functions on the **Catlg** menu can be incorporated into a definition. The **Catlg** menu is one of the Toolbox menus ( ). The following definition incorporates a command from that menu and an app variable: `F6(X)=X²+INT(Root)`. The integer value of the last root calculated in the Function app is substituted for `INT(Root)` when this definition is evaluated.

- From other definitions

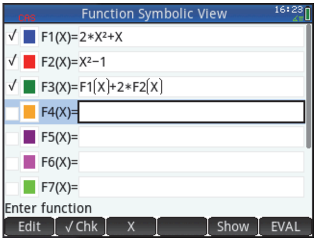
  You could, for example, define `F3(X)` as `F1(X)*F2(X)`.

Evaluate a dependent definition

If you have a dependent definition—that is, one defined in terms of another definition—you can combine all the definitions into one by evaluating the dependent definition.

1. Select the dependent expression.
2. Tap Eval.

Consider the example at the right. Notice that `F3(X)` is defined in terms of two other functions. It is a dependent definition and can be evaluated. If you highlight `F3(X)` and tap Eval, `F3(X)` becomes `2*X²+X+ 2*(X²-1)`.



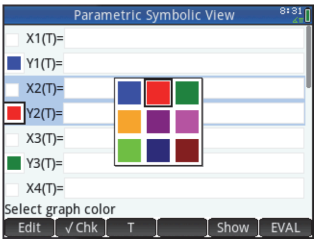
Select or deselect a definition to explore

In the Advanced Graphing, Function, Parametric, Polar, Sequence, and Solve apps you can enter up to 10 definitions. However, only those definitions that are selected in Symbolic view will be plotted in Plot view and evaluated in Numeric view.

You can tell if a definition is selected by the tick (or checkmark) beside it. A checkmark is added by default as soon as you create a definition. So if you don't want to plot or evaluate a particular definition, highlight it and tap √. (Do likewise if you want to re-select a deselected function.)

Choose a color for plots

Each function and open sentence can be plotted in a different color. If you want to change the default color of a plot:



1. Tap the colored square to the left of the function's definition.

   You can also select the square by pressing Enter while the definition is selected. Pressing Enter moves the selection from the definition to the colored square and from the colored square to the definition.
2. tap Choose.
3. Select the desired color from the color-picker.

Delete a definition

To delete a single definition:

1. Tap once on it (or highlight it using the cursor keys).
2. Press Del.

To delete all the definitions:

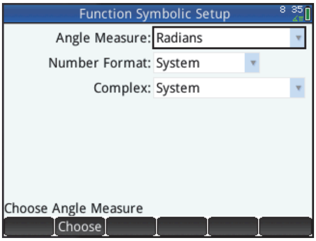
1. Press Shift Esc Clear.
2. Tap OK or press Enter to confirm your intention.

Symbolic view: Summary of menu buttons

Button	Purpose
Edit	Copies the highlighted definition to the entry line for editing. Tap OK when done. To add a new definition—even one that is replacing an existing one—highlight the field and just start entering your new definition.
√	Selects (or deselects) a definition.
X [Function only]	Enters the independent variable in the Function app. You can also press xtθn.
X [Advanced Graphing only]	Enters an X in the Advanced Graphing app. You can also press xtθn.
Y [Advanced Graphing only]	Enters an Y in the Advanced Graphing app.
T [Parametric only]	Enters the independent variable in the Parametric app. You can also press xtθn.
θ [Polar only]	Enters the independent variable in the Polar app. You can also press xtθn.
N [Sequence only]	Enters the independent variable in the Sequence app. You can also press xtθn.
= [Solve only]	Enters the equals sign in the Solve app. A shortcut equivalent to pressing Shift ≐.
Show	Displays the selected definition in full-screen mode. See "Large results" on page 36 for more information.
Eval	Evaluates dependent definitions. See "Evaluate a dependent definition" on page 74.

Common operations in Symbolic Setup view

[Scope: all apps]



The Symbolic Setup view is the same for all apps. Its primary purpose is to allow you to override three of the system-wide settings specified on the **Home Settings** window.

Press Shift Symb (Setup) to open Symbolic Setup view.

Override system-wide settings

1. Tap once on the setting you want to change.

   You can tap on the field name or the field.

2. Tap again on the setting.

   A menu of options appears.

3. Select the new setting.

   Note that selecting the `Fixed`, `Scientific`, or `Engineering` option on the **Number Format** menu displays a second field for you to enter the required number of significant digits.

You could also select a field, tap Choose, and select the new setting.

Restore default settings

To restore default settings is to return precedence to the settings on the **Home Settings** screen.

To restore one field to its default setting:

1. Select the field.
2. Press Del.

To restore all default settings, press Shift Esc (Clear).

Common operations in Plot view

Plot view functionality that is common to many apps is described in detail in this section. Functionality that is available only in a particular app is described in the chapter dedicated to that app.

Press Plot (Setup) to open Plot view.

Zoom

[Scope: Advanced Graphing, Function, Parametric, Polar, Sequence, Solve, Statistics 1 Var, and Statistics 2Var. Also, to a limited degree, Geometry.]

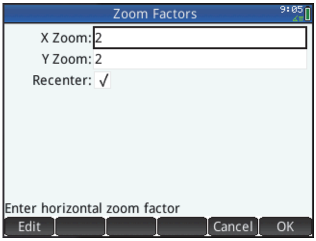
Zooming redraws the plot on a larger or smaller scale. It is a shortcut for changing the range settings in Plot Setup view. The extent of most zooms is determined by two zoom factors: a horizontal and a vertical factor. By default, these factors are both 2. Zooming out *multiplies* the scale by the factor, so that a greater scale distance appears on the screen. Zooming in *divides* the scale by the factor, so that a shorter scale distance appears on the screen.

Zoom factors

To change the default zoom factors:

1. Open the Plot view of the app (Plot Setup).
2. Tap Menu to open the Plot view menu.
3. Tap Zoom to open the Zoom menu.
4. Scroll and select **Set Factors.**

   The **Zoom Factors** screen appears.



5. Change one or both zoom factors.
6. If you want the plot to be centered around the current position of the cursor in Plot view, select **Recenter**.
7. Tap OK or press Enter ≈.

Zoom options

Zoom options are available from three sources:

- the keyboard
- the Zoom menu in Plot view
- the **Views** menu (View Copy).

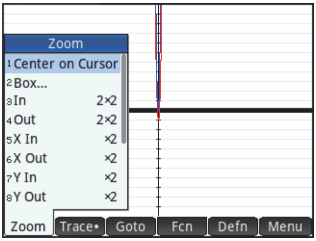
Zoom keys

There are two zoom keys: pressing + zooms in and pressing − zooms out. The extent of the scaling is determined by the **ZOOM FACTOR** settings (explained above).

Zoom menu

In Plot view, tap Zoom and tap an option. (If Zoom is not displayed, tap Menu.)

The zoom options are explained in the following table. Examples are provided on "Zoom examples" on page 81.



Option	Result
Center on Cursor	Redraws the plot so that the cursor is in the center of the screen. No scaling occurs.
Box	Explained in "Box zoom" on page 80.
In	Divides the horizontal and vertical scales by **X Zoom** and **Y Zoom** (values set with the **Set Factors** option explained on page 78). For instance, if both zoom factors are 4, then zooming in results in 1/4 as many units depicted per pixel. (Shortcut: press [+].)
Out	Multiplies the horizontal and vertical scales by the **X Zoom** and **Y Zoom** settings. (Shortcut: press [−].)
X In	Divides the horizontal scale only, using the **X Zoom** setting.
X Out	Multiplies the horizontal scale only, using the **X Zoom** setting.
Y In	Divides the vertical scale only, using the **Y Zoom** setting.
Y Out	Multiplies the vertical scale only, using the **Y Zoom** setting.
Square	Changes the vertical scale to match the horizontal scale. This is useful after you have done a box zoom, X zoom or Y zoom.

Option	Result (Cont.)
Autoscale	Rescales the vertical axis so that the display shows a representative piece of the plot given the supplied *x* axis settings. (For Sequence and Statistics apps, autoscaling rescales both axes.) The autoscale process uses the first selected function to determine the best scale to use.
Decimal	Rescales both axes so each pixel is 0.1 units. This is equivalent to resetting the default values for **XRNG** and **YRNG**.
Integer	Rescales the horizontal axis only, making each pixel equal to 1 unit.
Trig	Rescales the horizontal axis so that 1 pixel equals $\pi/24$ radians or 7.5 degrees; rescales the vertical axis so that 1 pixel equals 0.1 units.
Undo Zoom	Returns the display to the previous zoom, or if there has been only one zoom, displays the graph with the original plot settings.

Box zoom

A box zoom enables you to zoom in on an area of the screen that you specify.

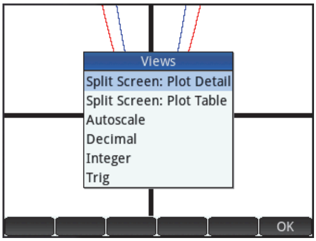
1. With the Plot view menu open, tap Zoom and select `Box`.
2. Tap one corner of the area you want to zoom in on and then tap OK.
3. Tap the diagonally opposite corner of the area you want to zoom in on and then tap OK.

   The screen fills with the area you specified. To return to the default view, tap Zoom and select `Decimal`.

Views menu

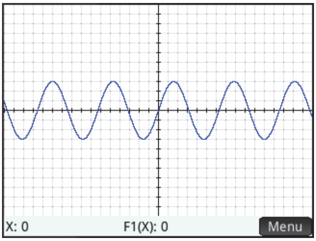
The most commonly used zoom options are also available on the **Views** menu. These are:

- Autoscale
- Decimal
- Integer
- Trig.



These options—which can be applied whatever view you are currently working in—are explained in the table immediately above.

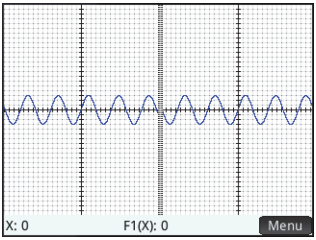
Testing a zoom with split-screen viewing



A useful way of testing a zoom is to divide the screen into two halves, with each half showing the plot, and then to apply a zoom only to one side of the screen. The illustration at the right is a plot of *y* = 3sin *x*. To split the screen into two halves:

1. Open the **Views** menu.

   Press View Copy



2. Select `Split Screen: Plot Detail`.

   The result is shown at the right. Any zoom operation you undertake will be applied only to the copy of the plot in the right-hand half of the screen. This will help you test and then choose an appropriate zoom.

Note that you can replace the original plot on the left with the zoomed plot on the right by tapping ←PLOT.

To un-split the screen, press Plot Setup.

Zoom examples

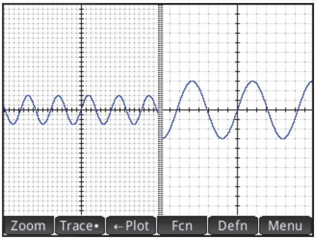
The following examples show the effects of the zooming options on a plot of $3\sin x$ using the default zoom factors (2 × 2). Split-screen mode (described above) has been used to help you see the effect of zooming.

Note that there is an `Unzoom` option on the **Zoom** menu. Use this to return a plot to its pre-zoom state. If the **Zoom** menu is not shown, tap Menu.

Zoom In

Zoom `In`

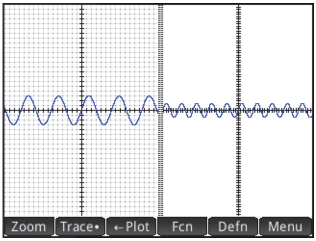
Shortcut: press + Ans



Zoom Out

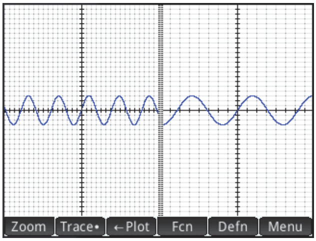
Menu Zoom Out

Shortcut: press −



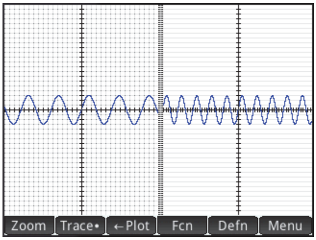
X In

Zoom X In



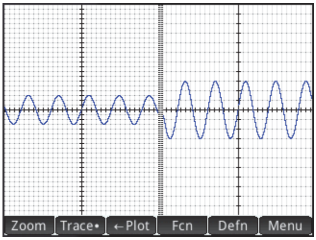
X Out

Zoom X Out



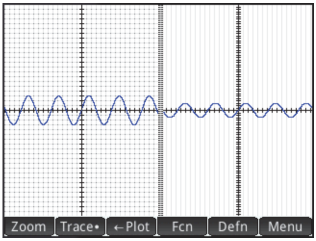
Y In

Zoom Y In



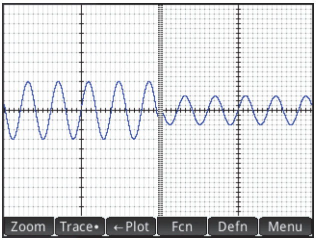
Y Out

Zoom Y Out



Square

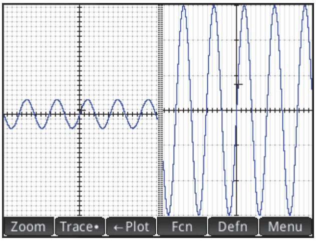
Zoom Square



Notice that in this example, the plot on left has had a Y In zoom applied to it. The Square zoom has returned the plot to its default state where the X and Y scales are equal.

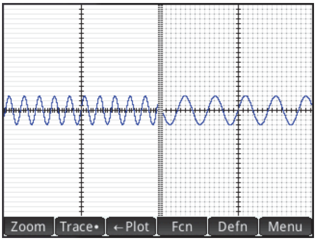
Autoscale

Zoom Autoscale



Decimal

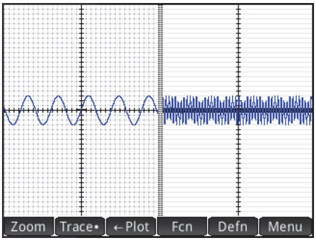
Zoom Decimal



Notice that in this example, the plot on left has had a X In zoom applied to it. The Decimal zoom has reset the default values for the *x*-range and *y*-range.

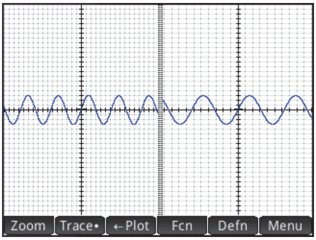
Integer

Zoom Integer



Trig

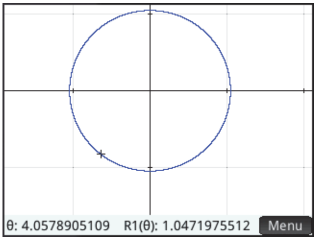
Zoom Trig



Trace

[Scope: Advanced Graphing, Function, Parametric, Polar, Sequence, Solve, Statistics 1 Var, and Statistics 2Var.]

The tracing functionality enables you to move a cursor (the *trace cursor*) along the current graph. You move the trace cursor by pressing ◀ or ▶. You can also move the trace cursor by tapping on or near the current plot. The trace cursor jumps to the point on the plot that is closest point to where you tapped.



The current coordinates of the cursor are shown at the bottom of the screen. (If menu buttons are hiding the coordinates, tap Menu to hide the buttons.)

Trace mode and coordinate display are automatically turned on when a plot is drawn.

To select a plot

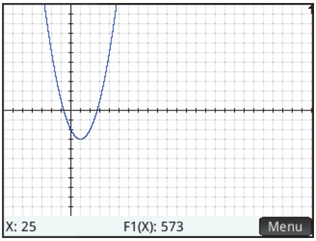
If there is more than one plot displayed, press ▲ or ▼ until the trace cursor is on the plot you are interested in.

To evaluate a definition

One of the primary uses of the trace functionality is to evaluate a plotted definition. Suppose in Symbolic view you have defined `F1(X)` as `(X–1)`^{2}`–3`. Suppose further that you want to know what the value of that function is when X is 25.

1. Open Plot view (Plot Setup).
2. If the menu at the bottom of the screen is not open, tap Menu.
3. If more than one definition is plotted, ensure that the trace cursor is on the plot of the definition you want to evaluate. You can press Defn to see the definition of a plot, and press ▲ or ▼ to move the trace cursor from plot to plot.
4. If you pressed Defn to see the definition of a plot, the menu at the bottom of the screen will be closed. Tap Menu to re-open it.
5. Tap Go To.
6. Enter 25 and tap OK.
7. Tap Menu.

The value of `F1(X)` when X is 25 us shown at the bottom of the screen. .



This is one of many ways the HP Prime provides for you to evaluate a function for a specific independent variable. You can also evaluate a function in Numeric view (see page 92). Moreover, any expression you define in Symbolic view can be evaluated in Home view. For example, suppose `F1(X)` is defined as $(x-1)^2-3$. If you enter `F1(4)` in Home view and press Enter you get 6, since $(4-1)^2-3 = 6$.

To turn tracing on or off

- To turn off tracing, tap TRACE•.
- To turn on tracing, tap Trace•.

If these options are not displayed, tap Menu.

When tracing is off, pressing the cursor keys no longer constrains the cursor to a plot.

Plot view: Summary of menu buttons

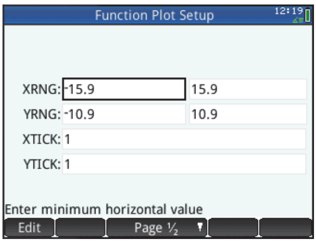
Button	Purpose
Zoom	Displays a menu of zoom options. See “Zoom options” on page 78.
Trace•	A toggle button for turning off and turning on trace functionality. See “Trace” on page 84.
Go To	Displays an input form for you to specify a value you want the cursor to jump to. The value you enter is the value of the independent variable.
Fcn [Function only]	Displays a menu of options for analyzing a plot. See “Analyzing functions” on page 109.
Defn	Displays the definition responsible for generating the selected plot.
Menu	A toggle button that shows and hides the other buttons across the bottom of the screen.

Common operations in Plot Setup view

This section covers only operations common to the apps mentioned. See the chapter dedicated to an app for the app-specific operations done in Plot Setup view.

Press Shift Plot (Setup) to open Plot Setup view.

Configure Plot view



[Scope: Advanced Graphing, Function, Parametric, Polar, Sequence, Statistics 1 Var, Statistics 2Var]

The Plot Setup view is used to configure the appearance of Plot view and to set the method by which graphs are plotted. The configuration options are spread across two pages. Tap Page ½ to move from the first to the second page, and Page 2/2 to return to the first page.

Tip When you go to Plot view to see the graph of a definition selected in Symbolic view, there may be no graph shown. The likely cause of this is that the spread of plotted values is outside the range settings in Plot Setup view. A quick way to bring the graph into view is to press View/Copy and select `Autoscale`. This also changes the range settings in Plot Setup view.

Page 1

Setup field	Purpose
TRNG [Parametric only]	Sets the range of T-values to be plotted. Note that here are two fields: one for the minimum and one for the maximum value.
TSTEP [Parametric only]	Sets the increment between consecutive T-values.
θ**RNG** [Polar only]	Sets the range of angle values to be plotted. Note that here are two fields: one for the minimum and one for the maximum value.
θ**STEP** [Polar only]	Sets the increment between consecutive angle values.
SEQPLOT [Sequence only]	Sets the type of plot: Stairstep or Cobweb.
NRNG [Sequence only]	Sets the range of N-values to be plotted. Note that here are two fields: one for the minimum and one for the maximum value.
HWIDTH [Stats 1 Var only]	Sets the width of the bars in a histogram.
HRNG [Stats 1 Var only]	Sets the range of values to be included in a histogram. Note that here are two fields: one for the minimum and one for the maximum value.

Setup field	Purpose (Cont.)
S*MARK [Stats 2 Var only]	Sets the graphic that will be used to represent a data point in a scatter plot. A different graphic can be used for each of the five analyses that can be plotted together.
XRNG	Sets the initial range of the *x*-axis. Note that here are two fields: one for the minimum and one for the maximum value. In Plot view the range can be changed by panning and zooming.
YRNG	Sets the initial range of the *y*-axis. Note that there are two fields: one for the minimum and one for the maximum value. In Plot view the range can be changed by panning and zooming.
XTICK	Sets the increment between tickmarks on the *x*-axis.
YTICK	Sets the increment between tickmarks on the *y*-axis.

Page 2

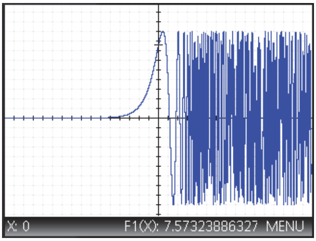
Setup field	Purpose
AXES	Shows or hides the axes.
LABELS	Places values at the ends of each axis to show the current range of values.
GRID DOTS	Places a dot at the intersection of each horizontal and vertical grid line.
GRID LINES	Draws a horizontal and vertical grid line at each integer *x*-value and *y*-value.
CURSOR	Sets the appearance of the trace cursor: standard, inverting, or blinking.
CONNECT [Stats 2 Var only]	Connects the data points with straight segments.

Setup field	Purpose (Cont.)
METHOD [Not in either statistics app]	Sets the graphing method to adaptive, fixed-step segments, or fixed-step dots. Explained below.

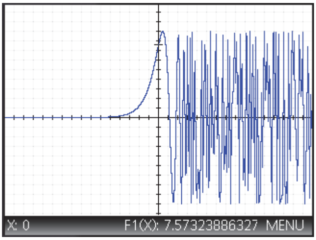
Graphing methods

The HP Prime gives you the option of choosing one of three graphing methods. The methods are described below, with each applied to the function $f(x) = 9*\sin(e^x)$.

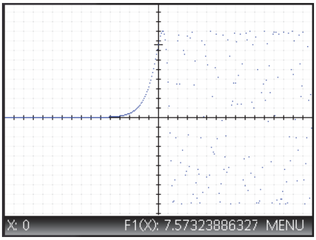
- *adaptive*: this gives very accurate results and is used by default. With this method active, some complex functions may take a while to plot. In these cases, Stop appears on the menu bar, enabling you to stop the plotting process if you wish.



- *fixed-step segments*: this method samples *x*-values, computes their corresponding *y*-values, and then plots and connects the points.



- *fixed-step dots*: this works like fixed-step segments method but does not connect the points.



Restore default settings

[Scope: Advanced Graphing, Function, Parametric, Polar, Sequence, Solve, Statistics 1 Var, Statistics 2Var, Geometry.]

To restore one field to its default setting:

1. Select the field.

2. Press Del.

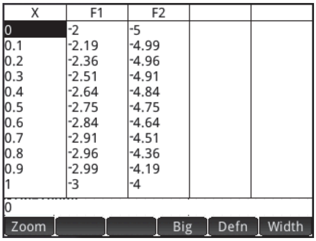
To restore all default settings, press Shift Esc (Clear).

Common operations in Numeric view

[Scope: Advanced Graphing, Function, Parametric, Polar]

Numeric view functionality that is common to many apps is described in detail in this section. Functionality that is available only in a particular app is described in the chapter dedicated to that app.

Numeric view provides a table of evaluations. Each definition in Symbolic view is evaluated for a range of values for the independent variable. You can set the range and fineness of the independent variable, or leave it to the default settings.



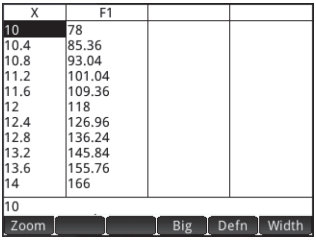
X	F1	F2		
0	-2	-5		
0.1	-2.19	-4.99		
0.2	-2.36	-4.96		
0.3	-2.51	-4.91		
0.4	-2.64	-4.84		
0.5	-2.75	-4.75		
0.6	-2.84	-4.64		
0.7	-2.91	-4.51		
0.8	-2.96	-4.36		
0.9	-2.99	-4.19		
1	-3	-4		

Press Num (Setup) to open Numeric view.

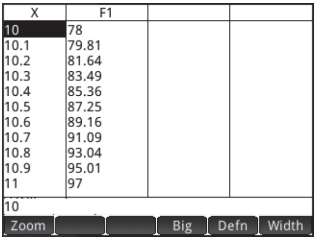
Zoom

Unlike in Plot view, zooming in Numeric view does not affect the size of what is displayed. Instead, it changes the increment between consecutive values of the independent variable (that is, the **NUMSTEP** setting in the Numeric Setup view: see page 95). Zooming in decreases the increment; zooming out increases the increment. The row that was highlighted before the zoom remains unchanged.

For the ordinary zoom in and zoom out options, the degree of zooming is determined by the zoom factor. In Numeric view this is the **NUMZOOM** field in the Numeric Setup view. The default value is 4. Thus if the current increment (that is, the **NUMSTEP** value) is 0.4, zooming in will further divide that interval by four smaller intervals. So instead of *x*-values of 10, 10.4, 10,8, 11.2 etc., the *x*-values will be 10, 10.1, 10.2, 10.3, 10.4, etc. (Zooming out does the opposite: 10, 10.4, 10,8, 11.2 etc. becomes10, 11.6, 13.2, 14.8, 16.4, etc.).



Before zooming



After zooming

Zoom options

In Numeric view, zoom options are available from two sources:

- the keyboard
- the Zoom menu in Numeric view.

Note that any zooming you do in Numeric view does not affect Plot view, and vice versa. However, if you choose a zoom option from the **Views** menu (View Copy) while you are in Numeric view, Plot view is displayed with the plots zoomed accordingly. In other words, the zoom options on the **Views** menu apply only to Plot view.

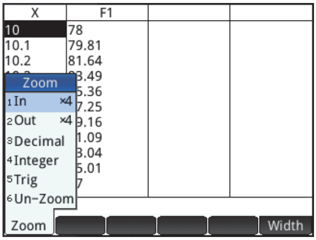
Zooming in Numeric view automatically changes the **NUMSTEP** value in the Numeric Setup view.

Zoom keys

There are two zoom keys: pressing + zooms in and pressing − zooms out. The extent of the scaling is determined by the **NUMZOOM** setting (explained above).

Zoom menu

In Numeric view, tap Zoom and tap an option.



The zoom options are explained in the following table.

Option	Result
In	The increment between consecutive values of the independent variable becomes the current value divided by the **NUMZOOM** setting. (Shortcut: press +.)
Out	The increment between consecutive values of the independent variable becomes the current value multiplied by the **NUMZOOM** setting. (Shortcut: press −.)
Decimal	Restores the default **NUMSTART** and **NUMSTEP** values: 0 and 0.1 respectively.
Integer	The increment between consecutive values of the independent variable is set to 1.
Trig	• If the angle measure setting is radians, sets the increment between consecutive values of the independent variable to π/24 (approximately 0.1309). • If the angle measure setting is degrees, sets the increment between consecutive values of the independent variable to 7.5.
Undo Zoom	Returns the display to the previous zoom, or if there has been only one zoom, displays the graph with the original plot settings.

Evaluating

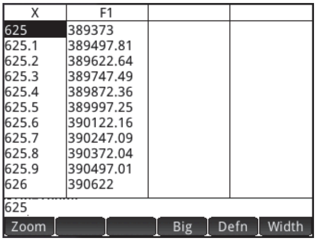
You can step through the table of evaluations in Numeric view by pressing ▲ or ▼. You can also quickly jump to an evaluation by entering the independent variable of interest in the independent variable column and tapping OK.

For example, suppose in the Symbolic view of the Function app, you have defined `F1(X)` as $(X-1)^2-3$. Suppose further that you want to know what the value of that function is when X is 625.

1. Open Numeric view (Num).
2. Anywhere in the independent column—the left-most column—enter 625.

3. Tap OK.

   Numeric view is refreshed, with the value you entered in the first row and the result of the evaluation in a cell to the right. In this example, the result is 389373.



Custom tables

If you choose `Automatic` for the **NUMTYPE** setting, the table of evaluations in Numeric view will follow the settings in the Numeric Setup view. That is, the independent variable will start with the **NUMSTART** setting and increment by the **NUMSTEP** setting. (These settings are explained in "Common operations in Numeric Setup view" on page 95.) However, you can choose to build your own table where just the values you enter appear as independent variables.

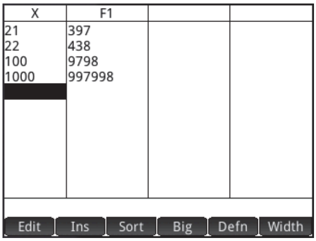
1. Open Numeric Setup view.

   Shift Num

2. Choose `BuildYourOwn` from the **NUMTYPE** menu.
3. Open Numeric view.

   Numeric view will be empty.

4. In the independent column—the left-most column—enter a value of interest.
5. Tap OK.
6. If you still have other values to evaluate, repeat from step 4.



Deleting data

To delete one row of data in your custom table, place the cursor in that row and press Del.

To delete all the data in your custom table:

1. Press Shift Esc.
2. Tap OK or press Enter to confirm your intention.

Numeric view: Summary of menu buttons

Button	Purpose
Zoom	To modify the increment between consecutive values of the independent variable in the table of evaluations. See page 90.
Edit [BuildYourOwn only]	To edit the value in the selected cell. To overwrite the value in the selected cell, you can just start entering a new value without first tapping Edit. Only visible if **NUMTYPE** is set to `BuildYourOwn`. See "Custom tables" on page 93.
Ins [BuildYourOwn only]	To create a new row above the currently highlighted cell, with zero as the independent value. You can immediately start typing a new value. Only visible if **NUMTYPE** is set to `BuildYourOwn`. See "Custom tables" on page 93.
Sort [BuildYourOwn only]	To sort the values in the selected column in ascending or descending order. Move the cursor to the column of interest, tap Sort, select `Ascending` or `Descending`, and tap OK. Only visible if **NUMTYPE** is set to `BuildYourOwn`. See "Custom tables" on page 93.
BIG	Toggles the display between medium and large font.
Defn	Toggles between showing the value of the cell and the definition that generated the value.

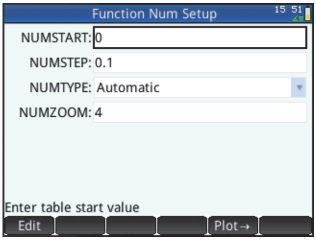
Button	Purpose (Cont.)
WIDTH	Displays a menu for you to choose to display the evaluations of 1, 2, 3, or 4 defintions. If you have more than four definitions seelcted in Symbolic view, you can press ▶ to scroll rightwards and see more columns. Pressing ◀ scrolls the columns leftwards.

Common operations in Numeric Setup view

[Scope: Advanced Graphing, Function, Parametric, Polar, Sequence]

Press Shift Num Setup to open Numeric Setup view.

The Numeric Setup view is used to:

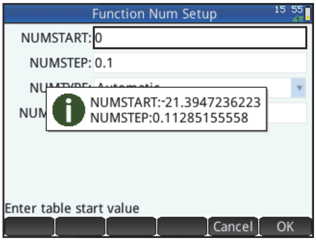


- set the starting number for the independent variable in automatic tables displayed in Numeric view: the **NUMSTART** field.
- set the increment between consecutive numbers in automatic tables displayed in Numeric view: the **NUMSTEP** field.
- specify whether the table of data to be displayed in Numeric view is to be based on the specified starting number and increment (automatic table) or to based on particular numbers for the independent variable that your specify (build-your-own table): the **NUMTYPE** field.
- set the zoom factor for zooming in or out on the table displayed in Numeric view: the **NUMZOOM** field.

Modifying Numeric Setup

Select the field you want to change and either specify a new value, or if you are choosing a type of table for Numeric view—automatic or build-your-own—choose the appropriate option from the **NUMTYPE** menu.

To help you set a starting number and increment that matches the current Plot view, tap PLOT→.



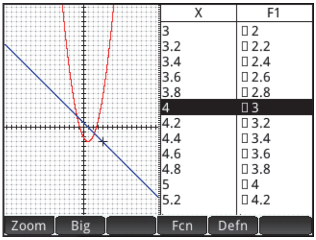
Restore default settings

To restore one field to its default setting:

1. Select the field.
2. Press Del.

To restore all default settings, press Shift Esc (Clear).

Combining Plot and Numeric Views



You can display Plot view and Numeric view side-by-side. Moving the tracing cursor causes the table of values in Numeric view to scroll. You can also enter a value in the `X` column. The table scrolls to that value, and the tracing cursor jumps to the corresponding point on the selected plot.

To combine Plot and Numeric view in a split screen, press View (Copy) and select `Split Screen: Plot Table`.

To return to Plot view, press Num (Setup). To return to Numeric view by pressing Num (Setup).

Adding a note to an app

You can add a note to an app. Unlike general notes—those created via the Note Catalog: see chapter 25—an app note is not listed in the Note Catalog. It can only be accessed when the app is open.

An app note remains with the app if the app is sent to another calculator.

To add a note to an app:

1. Open the app.

2. Press Shift Apps (Info).

   If a note has already been created for this app, its contents are displayed.

3. Tap Edit and start writing (or editing) your note.

   The format and bullet options available are the same as those in the Note Editor (described in "The Note Editor" on page 430).

4. To exit the note screen, press any key. Your note is automatically saved.

Creating an app

The apps that come with the HP Prime are built in and cannot be deleted. They are always available (simply by pressing Apps). However, you can create any number of customized instances of most apps. You can also create an instance of an app that is based on a previously customized app. Customized apps are opened from the application library in the same way that you open a built-in app.

The advantage of creating a customized instance of an app is that you can continue to use the built-in app for some other problem and return to the customized app at any time with all its data still in place. For example, you could create a customized version of the Sequence app that enables you to generate and explore the Fibonacci series. You could continue to use the built-in Sequence app to build and explore other sequences and return, as needed, to your special version of the Sequence app when you next want to explore the Fibonacci series. Or you could create a customized version of the Solve app—named, for example, `Triangles`—in which you set up, just once, the equations for solving common problems involving right-angled triangles (such as `H=O/SIN(θ)`, `A=H*COS(θ)`, `O=A*TAN(θ)`, etc.). You could continue to use the Solve app to solve other types of problems but use your Triangle app to solve problems involving right-angled triangles. Just open Triangles, select which equation to use—you won't need to re-enter them—enter the variables you know, and then solve for the unknown variable.

Like built-in apps, customized apps can be sent to another HP Prime calculator. This is explained in "Sharing data" on page 40.

Customized apps can also be reset, deleted, and sorted just as built-in apps can (as explained earlier in this chapter).

Note that the only apps that cannot be customized are the:

- Linear Explorer
- Quadratic Explorer and
- Trig Explorer apps.

Example

Suppose you want to create a customized app that is based on the built-in Sequence app. The app will enable you to generate and explore the Fibonacci series.

1. Press Apps Info and use the cursor keys to highlight the Sequence app. Don't open the app.
2. Tap Save. This enables you to create a copy of the built-in app and save it under a new name. Any data already in the built-in app is retained, and you can return to it later by opening the Sequence app.
3. In the **Name** field, enter a name for your new app—say, `Fibonacci`—and press Enter twice.

   Your new app is added to the Application Library. Note that it has the same icon as the parent app—Sequence—but with the name you gave it: `Fibonacci` in this example.

4. If you want to clear the new app of any data that was in the parent app, make sure your new app is highlighted in the Application Library and tap Reset. Tap OK when you are asked to confirm your intention.

   Note that this step is entirely optional. If you want to keep building on data that was in the parent app, then don't reset your new app.
5. You are now ready to use this app just as you would the built-in Sequence app. Tap on the icon of your new app to

open it. You will see in it all the same views and options as in the parent app.

In this example we have used the Fibonacci series as a potential topic for a customized app. To see how to create the Fibonacci series once inside the Sequence app—or an app based on the Sequence app—see chapter 16, “Sequence app”, beginning on page 257.

As well as cloning a built-in app—as described above—you can modify the internal workings of a customized app using the HP Prime programming language. See “Customizing an app” on page 460.

App functions and variables

Functions

App functions are used in HP apps to perform common calculations. For example, in the Function app, the Plot view **Fcn** menu has a function called `SLOPE` that calculates the slope of a given function at a given point. The `SLOPE` function can also be used from the Home view or a program.

For example, suppose you want to find the derivative of $x^2 - 5$ at $x = 2$. One way, using an app function, is as follows:

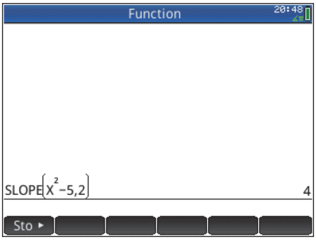
1. Press .
2. Tap App and select `Function` > `SLOPE`.

   `SLOPE()` appears on the entry line, ready for you to specify the function and the *x*-value.
3. Enter the function:

   5
4. Enter the parameter separator:

5. Enter the *x*-value and press Enter.

   The slope (that is the derivative) at $x = 2$ is calculated: 4.



All the app functions are described in “App menu”, beginning on page 312.

Variables

All apps have variables, that is, placeholders for various values that are unique to a particular app. These include symbolic expressions and equations, settings for the Plot and Numeric views, and the results of some calculations such as roots and intersections.

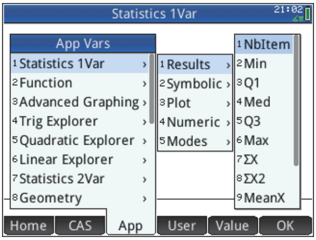
Suppose you are in Home view and want to retrieve the `mean` of a data set recently calculated in the Statistics 1Var app.

1. Press Vars.

   This opens the Variables menu. From here you can access Home variables, user-defined variables, and app variables.

2. Tap App.

   This opens a menu of app variables.



3. Select `Statistics 1Var` > `results` > `MeanX`.

   The current value of the variable you chose now appears on the entry line. You can press Enter to see its value. Or you can include the variable in an expression that you are building. For example, if you wanted to calculate the square root of the mean computed in the Statistics 1Var app, you would first press Shift x^2, follow steps 1 to 3 above, and then press Enter.

See appendix A, "Glossary", beginning on page 527 for a complete list of app variables.

Qualifying variables

You can qualify the name of any app variable so that it can be accessed from anywhere on the HP Prime. For example, both the Function app and the Parametric app have an variable named `Xmin`. If the app you last had open was the Parametric app and enter `Xmin` in Home view, you will get the value of `Xmin` from the Parametric app. To get the value of `Xmin` in the Function app instead, you could open the Function app and then return to Home view. Alternatively, you could qualify the name of the variable by preceding it with the app name and a period, as in `Function.Xmin`.

5

Function app

The Function app enables you to explore up to 10 real-valued, rectangular functions of y in terms of x; for example, $y = 1 - x$ and $y = (x - 1)^2 - 3$.

Once you have defined a function you can:

- create graphs to find roots, intercepts, slope, signed area, and extrema, and
- create tables that show how functions are evaluated at particular values.

This chapter demonstrates the basic functionality of the Function app by stepping you through an example. More-complex functionality is described in chapter 4, “An introduction to HP apps”, beginning on page 59.

Getting started with the Function app

The Function app uses the customary app views: Symbolic, Plot and Numeric described in chapter 4.

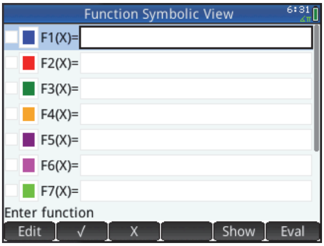
For a description of the menu buttons available in this app, see:

- “Symbolic view: Summary of menu buttons” on page 76
- “Plot view: Summary of menu buttons” on page 86, and
- “Numeric view: Summary of menu buttons” on page 94.

Throughout this chapter, we will explore the linear function $y = 1 - x$ and the quadratic function $y = (x - 1)^2 - 3$.

Open the Function app

1. Open the Function app.



   Apps Info Select `Function`

   Recall that you can open an app just by tapping its icon. You can also open it by using the cursor keys to highlight it and then pressing Enter.

   The Function app starts in Symbolic view. This is the *defining view*. It is where you symbolically define (that is, specify) the functions you want to explore.

   The graphical and numerical data you see in Plot view and Numeric view are derived from the symbolic expressions defined here.

Define the expressions

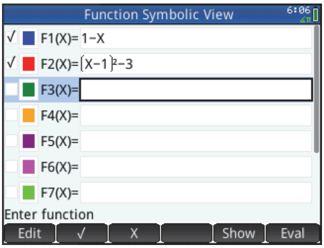
There are 10 fields for defining functions. These are labelled `F1(X)` through `F9(X)` and `F0(X)`.

2. Highlight the field you want to use, either by tapping on it or scrolling to it. If you are entering a new expression, just start typing. If you are editing an existing expression, tap Edit and make your changes. When you have finished defining or changing the expression, press Enter.

3. Enter the linear function in `F1(X)`.

   1 − $xt\theta n$ Enter

4. Enter the quadratic function in `F2(X)`.



   ( ) $xt\theta n$ − 1 ▶ x^2 − 3 Enter

NOTE

You can tap the X button to assist in the entry of equations. In the Function app, it has the same effect as pressing $xt\theta n$. (In other apps, $xt\theta n$ enters a different character.)

5. Decide if you want to:

   – give one or more function a custom color when it is plotted

   – evaluate a dependent function

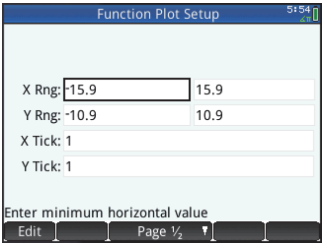
   – deselect a definition that you don't want to explore

   – incorporate variables, math commands and CAS commands in a definition.

   For the sake of simplicity we can ignore these operations in this example. However, they can be useful and are described in detail in "Common operations in Symbolic view" on page 71.

Set up the plot

You can change the range of the *x*- and y-axes and the spacing of the tick marks along the axes



6. Display Plot Setup view.

   Shift Plot Setup (Setup)

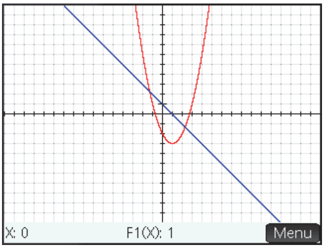
For this example, you can leave the plot settings at their default values. If your settings do not match those in the illustration above, press Shift Esc Clear (Clear) to restore the default values.

See "Common operations in Plot Setup view" on page 86 for more information about setting the appearance of plots.

Plot the functions

7. Plot the functions.

   Plot Setup

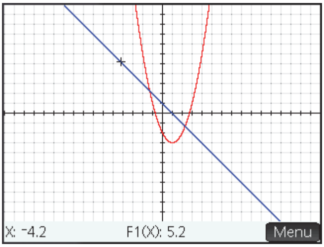


Trace a graph

8. By default, the trace functionality is active. This enables you to move a cursor along the contour of a plot. If more than two plots are shown, the plot that is the highest in the list of functions in Symbolic view is the plot that will be traced by default. Since the linear equation is higher than the quadratic function in Symbolic view, it is the plot on which the tracing cursor appears by default

9. Trace the linear function.

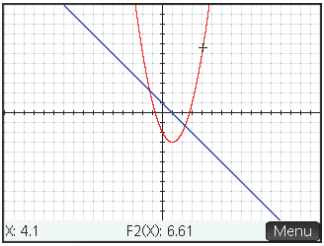
   ⊳ or ⊲



   Note how a cursor moves along the plot as you press the buttons. Note too that the coordinates of the cursor appear at the bottom of the screen and change as you move the cursor.

10. Move the tracing cursor from the linear function to the quadratic function.

    ⊳ or ⊲



11. Trace the quadratic function.

    ⊳ or ⊲

    Again notice how the coordinates of the cursor appear at the bottom of the screen and change as you move the cursor.

    Tracing is explained in more detail in "Trace" on page 84.

Change the scale

You can change the scale to see more or less of your graph. This can be done in four ways:

- Press [+ Ans] to zoom in or [− Base] to zoom out on the current cursor position. This method uses the zoom factors set in the **Zoom** menu. The default for both x and y is 2.

- Use the Plot Setup view to specify the exact x-range (`XRNG`) and y-range (`YRNG`) you want.
- Use options on the **Zoom** menu to zoom in or out, horizontally or vertically, or both, etc.
- Use options on the **View** menu (View/Copy) to select a pre-defined view. Note that the `Autoscale` option attempts to provide a best fit, showing as many of the critical features of each plot as possible.

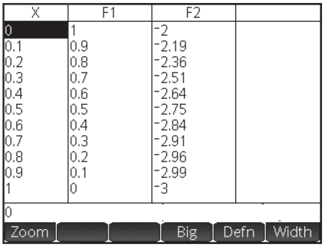
NOTE By dragging a finger horizontally or vertically across the screen, you can quickly see parts of the plot that are initially outside the set x and y ranges. This is easier than resetting the range of an axis.

Zoom options—with numerous examples—are explained in more detail in “Zoom” on page 78.

Display Numeric view

12. Display the Numeric view:

Num/Setup

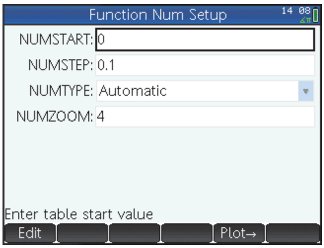


The Numeric view displays data generated by the expressions you defined in Symbolic view. For each expression selected in Symbolic view, Numeric view displays the value that results when the expression is evaluated for various *x*-values.

Set up Numeric view

13. Display the Numeric Setup view:

Shift Num/Setup (Setup)

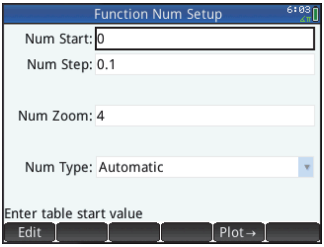


You can set the starting value and step value (that is, the increment) for the *x*-column, as well as the zoom factor for zooming in or out on a row of the table. Note that in Numeric view, zooming does not affect the size of what is displayed. Instead, it changes the **Num Step** setting (that is, the increment between consecutive *x*-values). Zooming in decreases the increment; zooming out increases the increment. This is further explained in “Zoom” on page 90.

You can also choose whether the table of data in Numeric view is automatically populated or whether it is populated by you typing in the particular *x*-values you are interested in. These options—`Automatic` or `BuildYourOwn`—are available from the **Num Type** list. They are explained in detail in “Custom tables” on page 93.

14. Press Shift Esc Clear (Clear) to reset all the settings to their defaults.

15. Make the Numeric view settings match the axes range in Plot view:



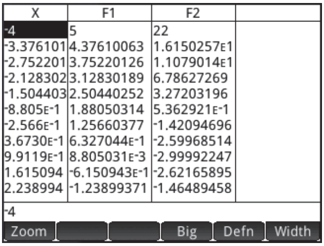
Tap PLOT→ OK.

For example, if you have zoomed in on the plot in Plot view so that the visible *x*-range is now –4 to 4, this option will set **NUMSTART** to –4.

Explore Numeric view

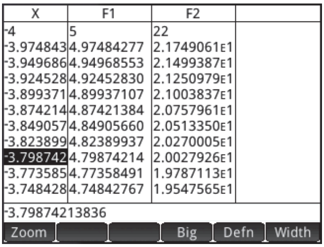
16. Re-display Numeric view:

Num Setup



To navigate around a table

17. Using the cursor keys, scroll through the values in the independent column (column `X`). Note that the values in the `F1` and `F2` columns match what you would get if you substituted the values in the `X` column for *x* in the

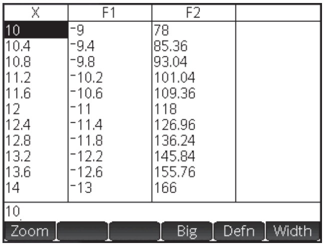


expressions selected in Symbolic view: `1-x` and `(x-1)`^{2}`-3`. You can also scroll through the columns of the dependant variables (labeled `F1` and `F2` in the illustration above).

To go directly to a value

18. Place the cursor is in the `X` column and type the desired value. For example, to jump straight to the row where *x* = 10:

    1 0 OK



To access the zoom options

Numerous zoom options are available by tapping Zoom. These are explained in “Zoom” on page 90. A quick way to zoom in (or zoom out) is to press + (or −). This zooms in (or out) by the **Num Zoom** value set in the Numeric Setup view (see page 107). The default value is 4. Thus if the current increment (that is, the **Num Step** value) is 0.4, zooming in will further divide that interval by four smaller intervals. So instead of *x*-values of 10, 10.4, 10,8, 11.2 etc., the *x*-values will be 10, 10.1, 10.2, 10.3, 10.4, etc. (Zooming out does the opposite: 10, 10.4, 10,8, 11.2 etc. becomes10, 11.6, 13.2, 14.8, 16.4, etc.)

Other options

As explained on page page 94, you can also:

- change the size of the font from medium to large
- display the definition responsible for generating a column of values
- choose to show 1, 2, 3, or 4 columns of data.

You can also combine Plot and Numeric view. See “Custom tables” on page 93.

Analyzing functions

The **Function** menu (Fcn) in Plot view enables you to find roots, intersections, slopes, signed areas, and extrema for any function defined in the Function app. If you have more than one function plotted, you may need to choose the function of interest beforehand.

Display the Plot view menu

The **Function** menu is a sub-menu of the Plot view menu. First, display the Plot view menu:

Plot Setup Menu

To find a root of the quadratic function

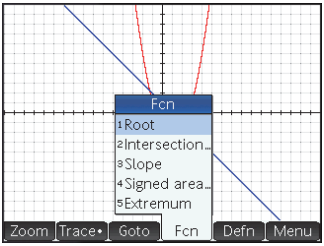
Suppose you want to find the root of the quadratic equation defined earlier. Since a quadratic equation can have more than one root, you will need to move the cursor closer to the root you are interested in than to any other root. In this example, you will find the root of the quadratic close to where $x = 3$.

1. If it is not already selected, select the quadratic equation:

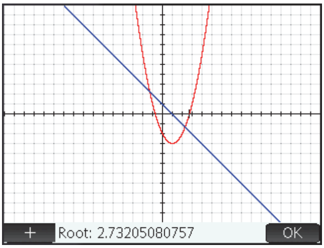
   ▲ or ▼

2. Press ▶ or ◀ to move the cursor near to where $x = 3$.

3. Tap Fcn and select `Root`

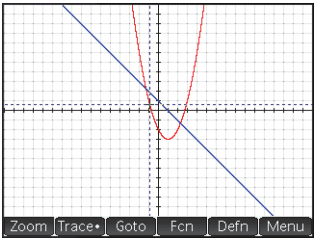


   The root is displayed at the bottom of the screen.



   If you now move the trace cursor close to $x = -1$ (the other place where the quadratic crosses the x-axis) and selected `Root` gain, the other toot is displayed.

Note the **+** button. If you tap this, one or two dotted lines pick out the point of interest (in this case a root). If, while this button is active, you tap elsewhere on the screen, a set of dotted lines appears on the screen. The dotted lines intersect the currently selected plot closest to the point you tapped. Their point of intersection is a tracing cursor. If you make another calculation where there is more than one answer, the answer that applies to the point closest to this tracing cursor is the answer provided. This is a faster way of choosing a point of interest than using the trace cursor. (You can move this tracing cursor using the cursor keys if you need finer precision.)



To find an intersection of the two functions

Just as there are two roots of the quadratic equation, there are two points at which both functions intersect. As with roots, you need to position your cursor closer to the point you are interested in. In this example, the intersection close to $x = 1$ will be determined.

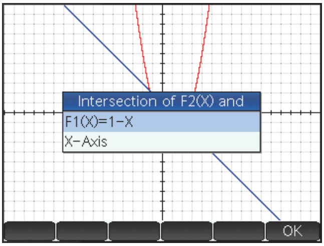
The **Go To** command is another way of moving the trace cursor to a particular point.

1. Tap **OK** to re-display the menu, tap **Go To**, enter **+/–** 1, and tap **OK**.

   The tracing cursor will now be on one of the functions at $x = 1$.

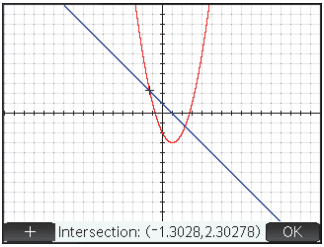
2. Tap **Fcn** and select `Intersection`.

   A list appears giving you a choice of functions and axes.



3. Choose the function whose point of intersection with the currently selected function you wish to find.

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



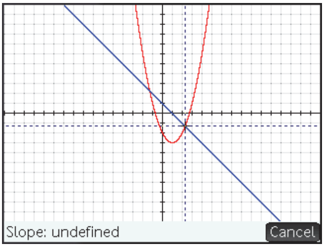
Tap + on the screen near the other intersection, and repeat from step 2. The coordinates of the intersection nearest to where you tapped are displayed at the bottom of the screen.

To find the slope of the quadratic function

We will now find the slope of the quadratic function at the intersection point.

1. Tap OK to re-display the menu, tap Fcn and select `Slope`.

   The slope (that is, the gradient) of the function at the intersection point is displayed at the bottom of the screen.

   You can press ◀ or ▶ to trace along the curve and see the slope at other points. You can also press ▲ or ▼ to jump to another function and see the slope at points on it.

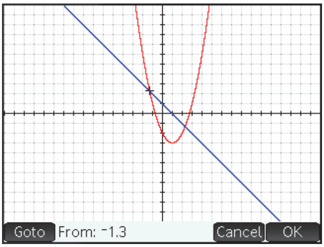
2. Press Cancel to re-display the Plot menu.

To find the signed area between the two functions

We'll now find the area between the two functions in the range $-1.3 \le x \le 2.3$.

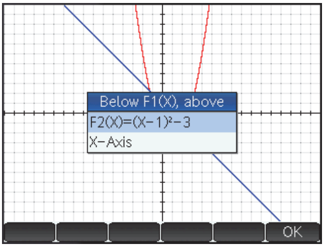
1. Tap Fcn and select `Signed area`.
2. Specify the start value for *x*:

   Tap Go To and press +/− 1 . 3 Enter.

3. Tap OK.

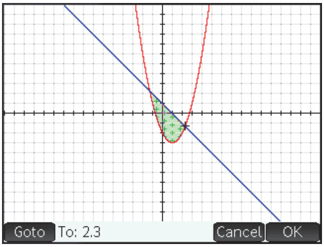
4. Select the other function as the boundary for the integral. (If F1(X) is the currently selected function, you would choose F2(X) here, and vice versa.)



5. Specify the end value for *x*:

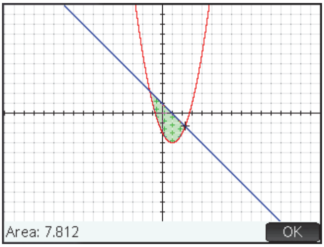
   Tap Go To and press 2 . 3 Enter.

   The cursor jumps to *x* = 2.3 and the area between the two functions is shaded.



6. To display the numerical value of the integral, tap OK.

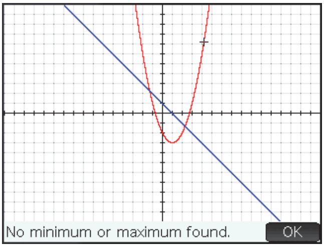
7. Tap OK to return to the Plot menu.



Shortcut: When the **Goto** option is available, you can display the **Go To** screen simply by typing a number. The number you type appears on the entry line. Just tap OK to accept it.

To find the extremum of the quadratic

1. To calculate the coordinates of the extremum of the quadratic equation, move the tracing cursor near to it (if necessary), tap Fcn and select `Extremum`.



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

NOTE The ROOT INTERSECTION, and EXTREMUM operations return only one value even if the function in question has more than one root, intersection, or extremum. The app will only return values that are closest to the cursor. You will need to move the cursor closer to other roots, intersections, or extrema if you want the app to calculate values for those.

The Function Variables

The result of each numerical analysis in the Function app is assigned to a variable. These variables are named:

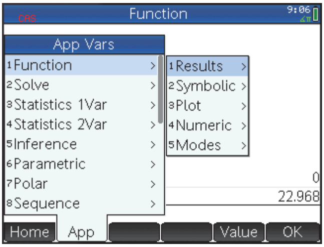
- Root
- Isect (for Intersection)
- Slope
- SignedArea
- Extremum

The result of each new analysis overwrites the previous result. For example, if you find the second root of a quadratic equation after finding the first, the value of Root changes form the first to the second root.

To access Function variables

The Function variables are available in Home view and in the CAS, where they can be included as arguments in calculations. They are also available in Symbolic view.

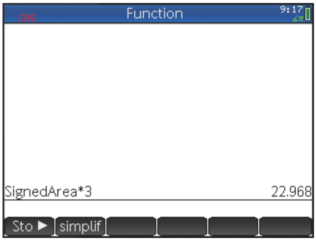
1. To access the variables, press Vars, tap App and select Function.



2. Select Results and then the variable of interest.

The variable's name is copied to the insertion point and its value is used in evaluating the expression that contains it.

For example, in Home view or the CAS you could select `SignedArea` from the **Vars** menus, press [×] 3 [Enter] and get the current value of `SignedArea` multiplied by three.



Function variables can also be made part of a function's definition in Symbolic view. For example, you could define a function as $x^2 - x - Root$.

The full range of variables, and their use in calculations, is covered in detail in chapter 21, "Variables", beginning on page 373.

Summary of FCN operations

Operation	Description
`Root`	Select `Root` to find the root of the current function nearest to the tracing cursor. If no root is found, but only an extremum, then the result is labeled `Extremum` instead of `Root`. The cursor is moved to the root value on the *x*-axis and the resulting *x*-value is saved in a variable named `Root`.
`Extremum`	Select `Extremum` to find the maximum or minimum of the current function nearest to the tracing cursor. The cursor moves to the extremum and the coordinate values are displayed. The resulting value is saved in a variable named `Extremum`.
`Slope`	Select `Slope` to find the numeric derivative of the current function at the current position of the tracing cursor. The result is saved in a variable named `Slope`.
`Signed area`	Select `Signed area` to find the numeric integral. (If there are two or more expressions checkmarked, then you will be asked to choose the second expression from a list that includes the *x*-axis.) Select a starting point and an ending point. The result is saved in a variable named `SignedArea`.
`Intersec-tion`	Select `Intersection` to find the intersection of the graph you are currently tracing and another graph. You need to have at least two selected expressions in Symbolic view. Finds the intersection closest to the tracing cursor. Displays the coordinate values and moves the cursor to the intersection. The resulting x-value is saved in a variable named `Isect`.

6

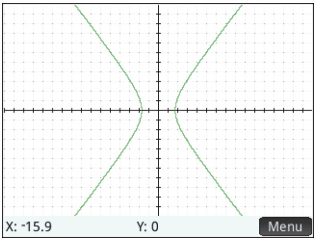
Advanced Graphing app

The Advanced Graphing app enables you to define and explore the graphs of symbolic open sentences in x, y, both or neither. You can plot conic sections, polynomials in standard or general form, inequalities, and functions. The following are examples of the sorts of open sentences you can plot:

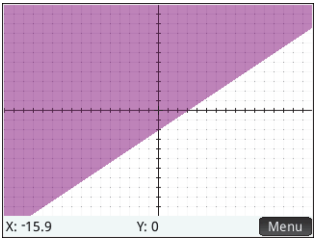
1. $x^2/3 - y^2/5 = 1$
2. $2x - 3y \le 6$
3. $y \text{ MOD } x = 3$
4. $\sin((\sqrt{x^2+y^2} - 5)^2) > \sin\left(8 \cdot \text{atan}\left(\frac{y}{x}\right)\right)$
5. $x^2 + 4x = -4$
6. $1 < 0$

The illustrations below show what these open sentences look like when plotted:

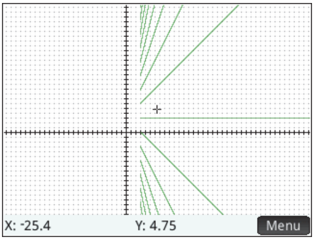
Example 1



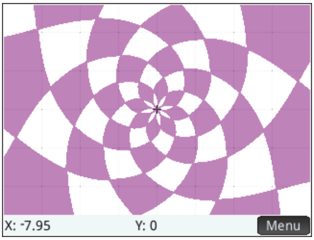
Example 2



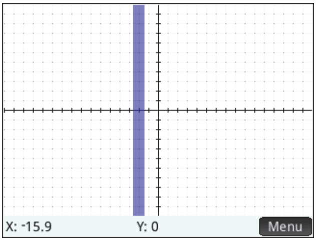
Example 3



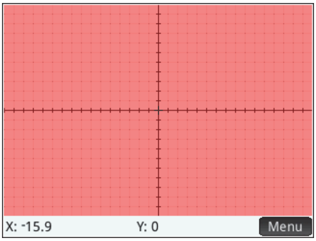
Example 4



Example 5



Example 6



Getting started with the Advanced Graphing app

The Advanced Graphing app uses the customary app views: Symbolic, Plot, and Numeric described in chapter 4.

For a description of the menu buttons available in this app, see:

- "Symbolic view: Summary of menu buttons" on page 76
- "Plot view: Summary of menu buttons" on page 86, and
- "Numeric view: Summary of menu buttons" on page 94.

The Trace option in the Advanced Graphing app works differently than in other apps and is described in detail in this chapter.

In this chapter, we will explore the rotated conic defined by:

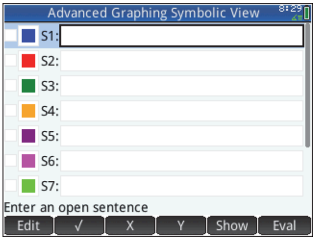
$$\frac{x^2}{2} - \frac{7xy}{10} + \frac{3y^2}{4} - \frac{x}{10} + \frac{y}{5} - 10 < 0$$

Open the app

1. Open the Advanced Graphing app:

   Apps Select `Advanced Graphing`

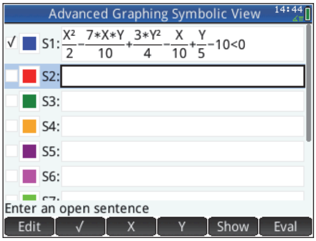
   The app opens in the Symbolic view.



Define the open sentence

2. Define the open sentence:

   X x² ÷ 2 ▶
   − 7 X Y
   ÷ 10 ▶ + 3
   Y x² ÷ 4 ▶
   − X ÷ 10
   ▶ + Y ÷ 5
   ▶ − 10 < 0 Enter



   Note that < can be easily selected from the relations palette: Shift 6.

3. Decide if you want to:

   – give one or more open sentence a custom color when it is plotted

   – evaluate a dependent function

   – deselect a definition that you don’t want to explore

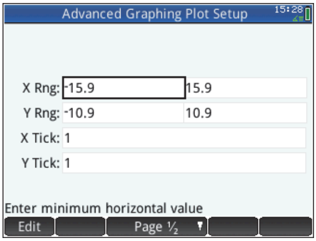
   – incorporate variables, math commands and CAS commands in a definition.

   For the sake of simplicity we can ignore these operations in this example. However, they can be useful and are described in detail in “Common operations in Symbolic view” on page 71.

Set up the plot

You can change the range of the *x*- and *y*-axes and the spacing of the interval marks along the axes.

4. Display Plot Setup view: Shift Plot (Setup)



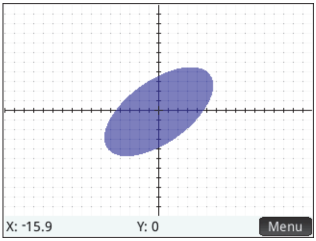
For this example, you can leave the plot settings at their default values. If your settings do not match those in the illustration at the right example, press Shift Esc (Clear) to restore the default values.

See "Common operations in Plot Setup view" on page 86 for more information about setting the appearance of plots.

Plot the selected definitions

5. Plot the selected definitions:

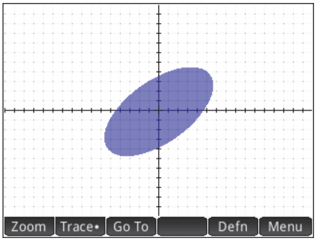
Plot



Explore the graph

6. Display the Plot view menu items:

Menu

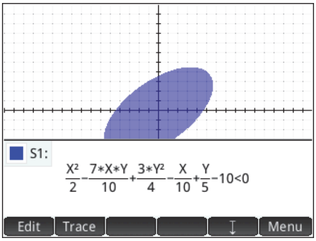


Note that you have otions to zoom, trace, go to a specified *x*- or *y*-value, and display the definition of the selected graph.

You can use the zoom and split screen functionality discussed in chapter 5.

A special feature of the Advanced Graphing app enables you to edit the definition of a graph from within the Plot view.

7. Tap Defn. The definition as you entered it in Symbolic view appears at the bottom of the screen.

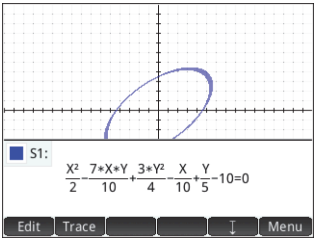


8. Tap Edit.

   The definition is now editable.

9. Change the < to = and tap OK.

   Notice that the graph changes to match the new definition. The definition in Symbolic view also changes.



10. Tap ↧ to drop the definition to the bottom of the screen so that you can see the full graph. The definition is converted from textbook mode to algebraic mode to save screen space.

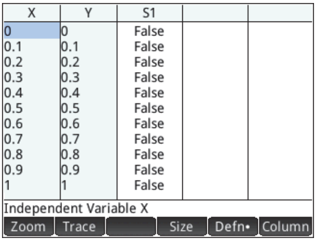
Trace a graph

[This functionality is not available as of build 3015]

Display the Numeric view

11. Press Num Setup to display the Numeric view.

    Unlike in many other apps, the Numeric view in the Advanced Graphing app does not give a table of values generated by the definitions selected in Symbolic view. Instead, for various combinations of *x* and y, Numeric view shows whether the open sentence is satisfied.



Explore Numeric view

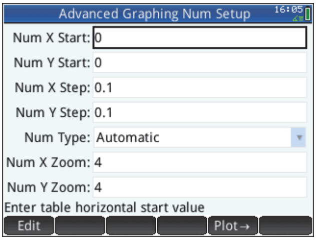
12. With the cursor in the X column, type a new value and tap OK. The table scrolls to the value you entered.

    You can also enter a value in the Y column and tap OK. Press ◀ and ▶ to move between the columns in Numeric view.

You can also zoom in or out on the X variable or Y variable (thereby decreasing or increasing the increment between consecutive values). This and other options are explained in “Common operations in Numeric view” on page 90.

Set up Numeric view

13. Display the Numeric Setup view:



Shift Num Setup (Setup)

You can set the starting value and step value (that is, the increment) for both the *X*-column and the *Y*-column, as well as the zoom factor for zooming in or out on a row of the table. Note that in Numeric view, zooming does not affect the size of what is displayed. Instead, it changes the **Num Step** setting (that is, the increment between consecutive *x*-values). Zooming in decreases the increment; zooming out increases the increment. This is further explained in “Zoom” on page 90.

You can also choose whether the table of data in Numeric view is automatically populated or whether it is populated by you typing in the particular *x*-values and *x*-values you are interested in. These options—`Automatic` or `BuildYourOwn`—are available from the **Num Type** list. They are explained in detail in “Custom tables” on page 93.

To make the Numeric view settings match the axes range in Plot view, tap PLOT→ OK.

7

Geometry

The Geometry app enables you to draw and explore geometric constructions. A geometric construction can be composed of any number of geometric objects, such as points, lines, polygons, curves, tangents, and so on. You can take measurements (such as areas and distances), manipulate objects, and note how measurements change.

There are five app views:

- Plot view: provides drawing tools for you to construct geometric objects
- Symbolic view: provides editable definitions of the objects in Plot view
- Numeric view: for making calculations about the objects in Plot view
- Plot Setup view: for customizing the appearance of Plot view
- Symbolic Setup view: for overriding certain system-wide settings

There is no Numeric Setup view in this app.

To open the Geometry app, press Apps Info and select **Geometry**. The app opens in Plot view.

Getting started with the Geometry app

The following example shows how you can graphically represent the derivative of a curve, and have the value of the derivative automatically update as you move a point of tangency along the curve. The curve to be explored is $y = 3\sin(x)$.

Since the accuracy of our calculation in this example is not too important, we will first change the number format to fixed at 3 decimal places. This will also help keep our geometry workspace uncluttered.

Preparation

1. Press Shift Settings.
2. On the **Home Setting** screen set the number format to `Fixed` and the number of decimal places to 3.

Open the app and plot the graph

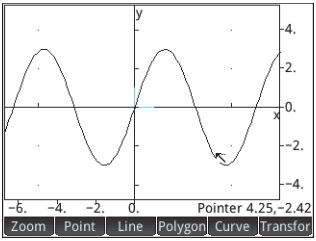
3. Press Apps Info and select **Geometry**.

   If there are objects showing that you don't need, press Shift Esc Clear and confirm your intention by tapping OK.
4. Select the type of graph you want to plot. In this example we are plotting a simple sinusoidal function, so choose:

   Curve > `Plot` > `Function`
5. With `plotfunc(` on the entry line, enter 3*sin(*x*):

   3 × SIN ASIN ALPHA alpha Shift × Enter ≈

   Note that *x* must be entered in lowercase in the Geometry app.

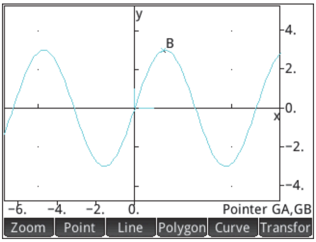
   If your graph doesn't resemble the illustration at the right, adjust the **X Rng** and **Y Rng** values in Plot Setup view (Shift Plot Setup).

   We'll now add a point to the curve, a point that will be constrained always to follow the contour of the curve.

Add a constrained point

6. Tap Point and select `Point On`.

   Choosing `Point On` rather than `Point` means that the point will be constrained to whatever it is placed on.
7. Tap anywhere on the graph, press Enter ≈ and then press Esc Clear.

   Notice that a point is added to the graph and given a name (`B` in this example). Tap a blank area of the screen to deselect everything. (Objects colored cyan are selected.)

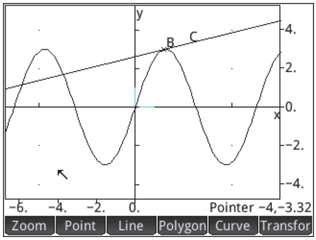
Add a tangent

8. We will now add a tangent to the curve, making point B the point of tangency:

   Line > More > Tangent

9. Tap on point B, press Enter and then press Esc.

   A tangent is drawn through point B. (Depending on where you placed point B, your illustration might be different from the one at the right.)

   We'll now make the tangent stand out by giving it a bright color.

10. If the curve is selected, tap a blank area of the screen to deselect, and then tap on the tangent to select it.

11. Press Menu and select Change Color.

12. Pick a color from the color-picker, press Esc and then tap on a blank area of the screen. Your tangent should now be colored.

13. Press Enter to select point B.

    If there is only one point on the screen, pressing Enter automatically selects it. If there is more than one point, a menu will appear asking you to choose a point.

14. With point B selected, use the cursor keys to move it about.

    Note that whatever you do, point B remains constrained to the curve. Moreover, as you move point B, the tangent moves as well. (If the moves off the screen, you can always bring it back by dragging your finger across the screen in the appropriate direction.)

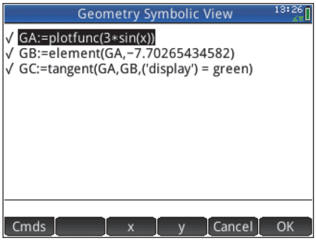
15. Press Esc to deselect point B.

Create a derivative point

The derivative of a graph at any point is the slope of its tangent at that point. We'll now create a new point that will be constrained to point B and whose ordinate value is the derivative of the graph at point B. We'll constrain it my forcing its *x* coordinate (that is, its abscissa) to always match that of point B, and its *y* coordinate (that is, its ordinate) to always equal the slope of the derivative at that point.

16. To define a point in terms of the attributes of other geometric objects, you need to go to Symbolic view:

    Symb Setup

    Note that each object you have so far created is listed in Symbolic view. Note too that the name for an object in Symbolic view is the name it was given in Plot view but prefixed with a "G". Thus the graph—labeled A in Plot view—is labeled GA in Symbolic view.

17. Highlight *GC* and tap New.

    When creating objects that are dependent on other objects, the order in which they appear in Symbolic view is important. Objects are drawn in Plot view in the order in which they appear in Symbolic view. Since we are about to create a new point that is dependent on the attributes of GB and GC, it is important that we place its definition after that of both GB and GC. That is why we made sure we were at the bottom the list of definitions before tapping New. If our new definition appeared higher up in Symbolic view, the point we are about to create wouldn't be drawn in Plot view.

18. Tap Cmds and choose Point > point

    You now need to specify the *x* and *y* coordinates of the new point. The former is to be constrained to abscissa of point B (referred to as GB in Symbolic view) and the later is to constrained to the slope of C (referred to as GC in Symbolic view).

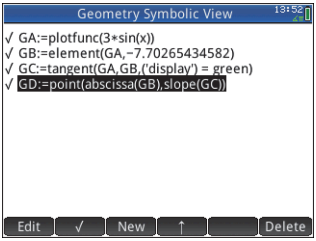
19. You should have `point()` on the entry line. Between the parentheses, add:

    `abscissa(GB),slope(GC)`

You can enter the commands by hand, or choose them from the **Catlg** menu (one of the five Toolbox menus).

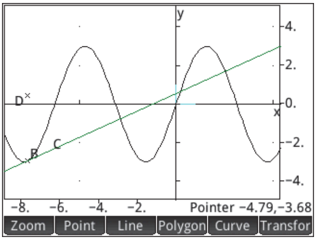
20. Tap OK.

The definition of your new point is added to Symbolic view. When you return to Plot view, you will see a point named `D` and it will have the same *x* coordinate as point `B`.



21. Press Plot Setup.

If you can't see point `D`, pan until it comes into view. The y coordinate of `D` will be the derivative of the curve at point `B`.



Since its difficult to read coordinates off the screen, we'll add a calculation that will give the exact derivative (to three decimal places) and which we can display in Plot view.

Add some calculations

22. Press Num Setup.

Numeric view is where you enter calculations.

23. Tap New.

24. Tap Cmds and choose `Measure > slope`

25. Between parentheses, add the name of the tangent, namely `GC`, and tap OK.

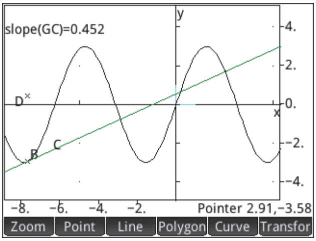
Notice that the current slope is calculated and displayed. The value here is dynamic, that is, if the slope of the tangent changes in Plot view, the value of the slope is automatically updated in Numeric view.

26. With the new calculation highlighted in Numeric view, tap √.

Selecting a calculation in Numeric view means that it will also be displayed in Plot view.

27. Press Plot (Setup) to return to Plot view.

    Notice the calculation that you have just created in Numeric view is displayed at the top left of the screen.



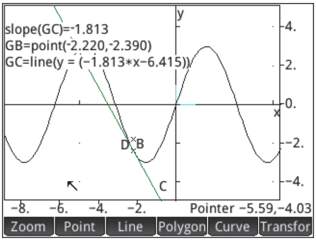
    Let’s now add two more calculations to Numeric view and have them displayed in Plot view.

28. Press Num (Setup) to return to Numeric view.
29. Tap New, enter GB, and tap OK.

    Entering just the name of a point will show its coordinates.
30. Tap New, enter GC, and tap OK.

    Entering just the name of a line will show its equation.
31. Make sure both of these new equations are selected (by choosing each one and pressing √).
32. Press Plot (Setup) to return to Plot view.

    Notice that your new calculations are displayed.



33. Press Enter and choose point GB.
34. Use the cursor keys to move point B along the graph. Note that with each move, the results of the calculations shown at the top left of the screen change.

Trace the derivative

Point D is the point whose ordinate value matches the derivative of the curve at point B. It is easier to see how the derivative changes by looking at a plot of it rather than comparing subsequent calculations. We can do that by tracing point D as it moves in response to movements of point B.

First we’ll hide the calculations so that we can better see the trace curve.

35. Press Num Setup to return to Numeric view.

36. Select each calculation in turn and tap √ . All calculations should now be deselected.

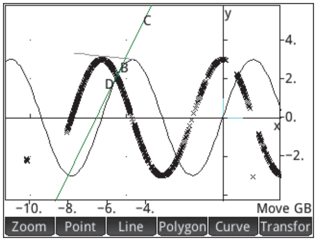
37. Press Plot Setup to return to Plot view.

38. Press Enter and select point `GD`.

39. Tap Point and select `More` > `Trace`

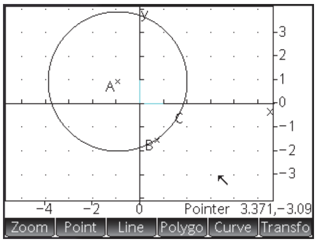
40. Press Enter and select point `GB`.

41. Using the cursor keys, move `B` along the curve. You will notice that a shadow curve is traced out as you move `B`. This is the curve of the derivative of 3sin(*x*).



Plot view in detail

In Plot view you can directly draw objects on the screen using various drawing tools. For example, For example, to draw a circle, tap Curve and select `Circle`. Now tap where you want the center of the circle to be and press Enter . Next, tap a point that is to be on the circumference and press Enter . A circle is drawn with a center at the location of your first tap, and with a radius equal to the distance between your first tap and second tap.



Creating or selecting an object always involves at least two steps: tap and press Enter . Only by pressing Enter do you confirm your intention to create the point or select an object. When creating a point, you can tap on the screen and then use the cursor keys to accurately position the point before pressing Enter .

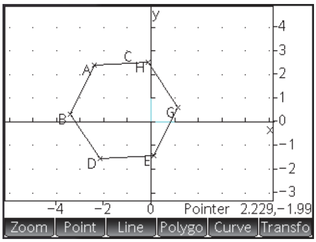
Note that there are on-screen instructions to help you. For example, `Hit Center` means tap where you want the center of your object to be, and `Hit Point 1` means tap at the location of the first point you want to add.

You can draw any number of geometric objects in Plot view. See “Geometric objects” on page 141 for a list of the objects you can draw. The drawing tool you choose—line, circle, hexagon, etc.—remains selected until you deselect it. This enables you to quickly draw a number of objects of the same type (such as a number of hexagons). Once you have finished drawing objects of a particular type, deselect the drawing tool by press Esc Clear. (You can tell if a drawing tool is still active by the presence of on-screen help at the top left-side corner of the screen, help such as `Hit Point 1`.)

An object in Plot view can be manipulated in numerous ways, and its mathematical properties can be easily determined (see page 138).

Object naming

Each geometric object you create is given a name. In the example shown on page 129, note that the circle has been named `C`. Each defining point is also been named: the center point has been named `A`, and the point tapped to set the radius of the circle has been named `B`.



It is not only the points that define a geometric object that are given a name. Every component of the object that has any geometric significance is also named. If, for example, you create a hexagon, the hexagon is given a name as is each point at each vertex. In the example at the right, the pentagon is named C, the points used to define the hexagon are named A and B, and the remaining four vertices are named D, E, G, and H. Moreover, each of the six segments is also given a name: I, J, K, L, M, and N. These names are not displayed in Plot view, but you can see them if you go to Symbolic view (see “Symbolic view in detail” on page 136).

Naming objects and parts of objects enables you to refer to them in calculations. This is explained in “Numeric view in detail” on page 138.

You can rename an object. See “Renaming an object” on page 137.

Selecting an object

To select an object, just tap on it. The color of a selected item changes to cyan.

To select a point in Plot view, just press Enter. A list of all the points appears. Select the one you want.

Hiding names

You can choose to hide the name of an object in Plot view:

1. Press Menu.
2. Select `Toggle Caption`.

   The **Select Object** menu appears.
3. Select the object whose label (that is, caption) you want to hide.
4. Press Esc.

Redisplay a hidden name by repeating this procedure.

Moving objects

Points To move a point press Enter. A list of all the points appears. Select the one you want to move, then tap on the new location for it, and press Enter. You can also press the arrow keys to move a selected point. A point can be selected directly by tapping on it. (If the bottom-right of the screen shows the name of the point, you have accurately tapped the point; otherwise the pointer coordinates are shown, indicating that the point is not selected.)

Composite objects To move a multi-point object, see “Translation” on page 148.

Coloring objects

An object is colored black by default (and cyan when it is selected). If you want to change the color of an object:

1. Press Menu.
2. Select `Change Color`.

   The **Select Object** menu appears.
3. Select the object whose color you want to change.

   The **Choose Color** palette appears.
4. Select the color you want.
5. Press Esc.

Note that for object with closed contours (such as a circle or polygon) it is the fill color that is changed.

Filling objects

An object with closed contours (such as a circle or polygon) can be filled with color.

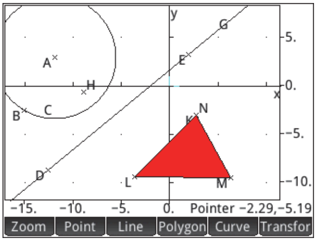
1. Press Menu Paste.
2. Select `Fill with Color`.

   The **Select Object** menu appears.
3. Select the object you want to fill.

   The object is highlighted.

1. Press Menu Paste.
2. Select `Change Color`.

   The **Choose Color** palette appears.
3. Select the color you want.
4. Press Esc Clear.



Removing fill

To remove the fill from an object:

1. Press Menu Paste.
2. Select `Fill with Color`.

   The **Select Object** menu appears.
3. Select the object.

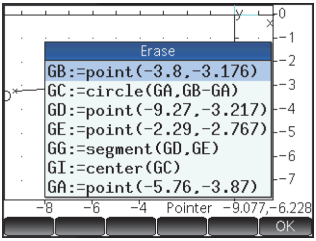
Undoing

You can undo your last addition or change to Plot view by pressing 4 Matrix U. However, you must have keyboard shortcuts activated for this to work. See page 135.

Clearing an object

To clear one object, select it and tap Del. Note that an object is distinct from the points you entered to create it. Thus deleting the object does not delete the points that define it. Those points remain in the app. For example, if you select a circle and press Del, the circle is deleted but the center point and radius point remain.

If you tap Del when no object is selected, a list of objects appears. Tap on the one you want to delete, and tap OK to confirm your intention. If you don't want to delete an object, press Esc Clear to close the list.



Note that points you add to an object once the object has been defined are cleared when you clear the object. Thus if you place a point (say `D`) on a circle and delete the circle, the circle and D are deleted, but the defining points—the center and radius points—remain.

Clearing all objects

To clear the app of all geometric objects, press Shift Esc Clear. You will be asked to confirm your intention to do so. Tap OK to clear the app, or Cancel to keep the app as it is,

Moving about the Plot view

You can pan by dragging a finger across the screen: either up, down, left, or right. You can also use the cursor keys to pan once the cursor is at the edge of the screen.

Zooming

You can zoom using touch gestures (see page 3) or by tapping Zoom and choosing a zoom option. The zoom options are the same as you find in the Plot view of many apps in the calculator (see "Zoom" on page 78).

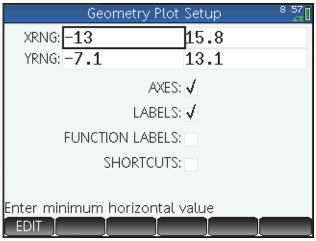
Plot view: buttons and keys

Button or key	Purpose
Zoom	Various scaling options. See "Zoom" on page 78.
Point	Tools for creating various types of points. See "Points" on page 141
Line	Tools for creating various types of lines. See "Line" on page 143
Polygon	Tools for creating various types of polygons. See "Polygon" on page 145

Button or key	Purpose (Continued)
Curve	Tools for creating various types of curves and plots. See "Curve" on page 146
Transfor	Tools for geometric transformations of various kinds. See "Geometric transformations" on page 148.
Del	Deletes a selected object (or the character to the left of the cursor if the entry line is active).
Esc Clear	De-activate the current drawing tool
Shift Esc Clear	Clears the Plot view of all geometric objects.
Shortcut keys	To quickly add an object, and undo what you've done. See page 135.

Plot Setup view

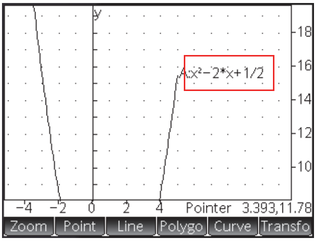
The Plot Set view enables you to configure the appearance of Plot view and to take advantage of keyboard shortcuts.The fields and options are:



- **X Rng**: Two fields for entering the minimum and maximum x-values, thereby giving the default horizontal range. As well as changing this range on the **Geometry Plot Setup** screen, you can change it by panning and zooming.
- **Y Rng**: Two fields for entering the minimum and maximum y-values, thereby giving the default vertical range. As well as changing this range on the **Geometry Plot Setup** screen, you can change it by panning and zooming.
- **Axes**: A toggle option to hide (or reshow) the axes in Plot view.

  Keyboard shortcut: Vars

- **Labels**: A toggle option to hide (or reshow) the names of the geometric objects (A, B, C, etc.) in Plot view.
- **Function Labels**: A toggle option to hide (or reshow) the expression that generated a plot with the plot. These should not be confused with calculation labels. You can show function labels without also showing calculation labels and vice versa).

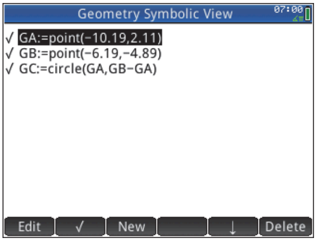


- **Shortcuts**: A toggle option to enable (or disable) keyboard shortcuts (that is, hot keys) in Plot view. With this option enabled, the following shortcuts become available:

Key	Result in Plot view
Vars (Chars A)	Hide (or reshow) the axes.
Units C	Selects the circle drawing tool. Follow the instructions on the screen (or see page 146).
a b/c (E)	Erases all trace lines (see page 142)
TAN (ATAN I)	Selects the intersection drawing tool. Follow the instructions on the screen (or see page 142).
x^2 (√ L)	Selects the line drawing tool. Follow the instructions on the screen (or see page 143).
EEX (Sto▸ P)	Selects the point drawing tool. Follow the instructions on the screen (or see page 141).
9 (S)	Selects the segment drawing tool. Follow the instructions on the screen (or see page 143).
÷ (x^{-1} T)	Selects the triangle drawing tool. Follow the instructions on the screen (or see page 145).

Key	Result in Plot view (Continued)
4 Matrix U	Undo.

Symbolic view in detail



Every object—whether a point, segment, line, polygon, or curve—is given a name, and its definition is displayed in Symbolic view (Symb Setup). The name is the name for it you see in Plot view, but prefixed by “G”. Thus a point labeled A in Plot view is given the name GA in Symbolic view.

The G-prefixed name is a variable that can be read by the computer algebra system (CAS). Thus in the CAS you can include such variables in calculations. Note in the illustration above that GC is the name of the variable that represents a circle drawn in Plot view. If you are working in the CAS and wanted to know what the area of that circle is, you could enter `area(GC)` and press Enter. (The CAS is explained in chapter 3.)

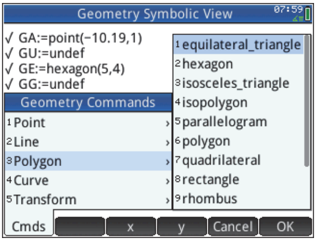
NOTE Calculations referencing geometry variables can only be made in the CAS or in the Numeric view of the Geometry app (explained below on page 138). They cannot be made in Home view.

You can change the definition of an object by selecting it, tapping Edit, and altering one or more of its defining parameters. The object is modified accordingly in Plot view. For example, if you selected point `GB` in the illustration above, tapped Edit, changed one or both of the point’s coordinates, and tapped OK, you would find, on returning to Plot view, a circle of a different size.

Creating objects You can also create an object in Symbolic view. Tap New, define the object—for example, `point(4,6)`—and press Enter. The object is created and can be seen in Plot view.

Another example: to draw aline through points P and Q, enter `line(GP,GQ)` in Symbolic view and press Enter. When you return to Plot view, you will see a line passing through points P and Q.

The object-creation commands available in Symbolic view can be seen by tapping Cmds. The syntax for each command is given in “Geometry functions and commands” on page 151



Re-ordering entries

You can re-order the entries in Symbolic view. Objects are drawn in Plot view in the order in which they are defined in Symbolic view. To change the position of an entry, highlight it and tap either ↓ (to move it down the list) or ↑ (to move it up).

Hiding an object

To prevent an object displaying in Plot view, deselect it in Symbolic view:

1. Highlight the item to be hidden.
2. Tap √.

Repeat the procedure to make the object visible again.

Deleting an object

As well as deleting an object in Plot view (see page 132) you can delete an object in Symbolic view.

1. Highlight the definition of the object you want to delete.
2. Tap Delete or press Del.

To delete all objects, press Shift Esc Clear.

Renaming an object

You can change the name that is automatically given to an object. For example, you could rename a circle from `GC` to `GCircle`, or rename one square from `GJ` to `GHouse` and another from `GL` to `GPaddock`. The new names will also appear in Plot view (and can also be referenced in Numeric view and in the CAS).

Note that a name must be a single string of characters (that is, it must contain no spaces). Also, the G prefix must be retained.

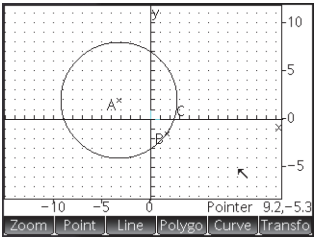
1. Highlight the definition of the object you want to rename.
2. Tap Renam.
3. Make your change and tap OK. [Functionality removed as at 3015]

Symbolic Setup view

The Symbolic view of the Geometry app is common with many apps. It is used to override certain some system-wide settings. For details, see “Symbolic Setup view” on page 64.

Numeric view in detail

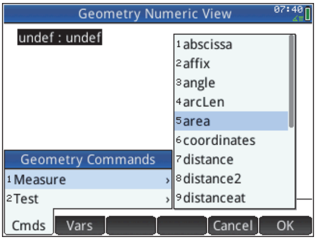
Numeric view (Num Setup) enables you to do calculations in the Geometry app. The results displayed are dynamic—if you manipulate an object in Plot view or Symbolic view, any calculations in Numeric view that refer to that object are automatically updated to reflect the new properties of that object.



Consider circle `C` in the illustration at the right. To calculate the area and radius of `C`:

1. Press Num Setup to open Numeric view.
2. Tap New.
3. Tap Cmds and choose `Measure > Area`.

   Note that `area()` appears on the entry line, ready fro you specify the object whose area you are interested in.

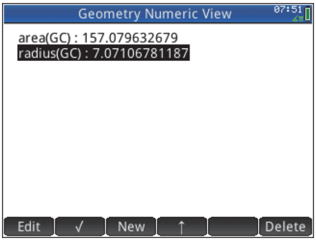


All the Geometry commands are explained in “Geometry functions and commands” on page 151.

4. Tap Vars, choose `Curves` and then the curve whose area you are interested in.

   The name of the object is placed between the parentheses.

   You could have entered the command and object name manually, that is, without choosing them from menus. If you enter object names manually, remember that the name of the object in Plot view must be given a “G” prefix if it is used in any calculation. Thus the circle named `C` in Plot view must be referred to as `GC` in Numeric view and Symbolic view.
5. Press Enter or tap OK. The area is displayed.
6. Tap New.
7. Enter `radius(GC)` and tap OK. The radius is displayed.

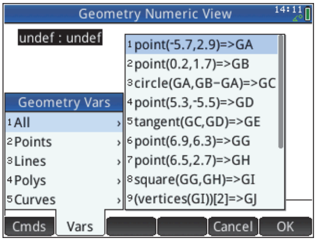


   Note that the syntax used here is the same as you use in the CAS to calculate the properties of geometric objects.

   The Geometry functions and their syntax are described in “Geometry functions and commands” on page 151.
8. Press Plot Setup to go back to Plot view. Now manipulate the circle is some way that changes its area and radius. For example, select the center point (`A`) and use the cursor keys to move it to a new location. (Remember to press Enter when you have finished.)
9. Press Num Setup to go back to Numeric view. Notice that the area and radius calculations have been automatically updated.

NOTE If an entry in Numeric view is too long for the screen, you can press ▶ to scroll the rest of the entry into view. Press ◀ to scroll back to the original view.

Listing all objects



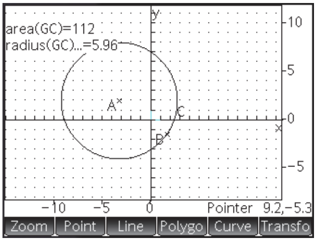
When you are creating a new calculation in Numeric view, the Vars menu item appears. Tapping Vars gives you a list of all the objects in your Geometry workspace. These are also grouped according to their type, with each group given its own menu.

If you are building a calculation, you can select an object from one of these variables menus. The name of the selected object is placed at the insertion point on the entry line.

Getting object properties

As well as employing functions to make calculations in Numeric view, you can also get various parameters of objects just by tapping New specifying the object's name. For example, you can get the exact coordinates of a point by entering the point and pressing Enter. Another example: if you can get the formula for a line just by entering its name, or the center point and radious of a circle just by entering the name of the circle.

Displaying calculations in Plot view



To have a calculation made in Numeric view appear in Plot view, just highlight it in Numeric view and tap √. A checkmark appears beside the calculation.

Repeat the procedure to prevent the calculation being displayed in Plot view. The checkmark is cleared.

Editing a calculation

1. Highlight the calculation you want to delete.
2. Tap Edit.
3. Make your change and tap OK.

Deleting a calculation

1. Highlight the calculation you want to delete.
2. Tap Delete.

To delete all calculations, press Shift Esc Clear. Note that deleting a calculation does not delete any objects from Plot or Symbolic view.

Geometric objects

The geometric objects discussed in this section are those that can be created in Plot view. Objects can also be created in Symbolic view—more, in fact, than in Plot view—but these are discussed in “Geometry functions and commands” on page 151.

In Plot view, you choose a drawing tool to draw an object. The tools are listed in this section. Note that once you select a drawing tool, it remains selected until you deselect it. This enables you to quickly draw a number of objects of the same type (such as a number of circles). To deselect the current drawing tool, press Esc Clear. (You can tell if a drawing tool is still active by the presence of on-screen help in the top left-side corner of the screen, help such as `Hit Point 1`.)

The steps provided in this section are based on touch entry. For example, to add a point, the steps will tell you to *tap* on the screen where you want the point to be. However, you can also use the cursor keys to position the cursor where you want the point to be and then press Enter ≈.

The drawing tools for the geometric objects listed in this section can be selected from the menu buttons a the bottom of the screen. Some objects can also be entered using a keyboard shortcut. For example, you can select the triangle drawing tool by pressing ÷. (Keyboard shortcuts are only available if they ave been turned on in Plot Setup view. See page 134.)

Points

Tap Point to display a menu and submenus of options for entering various types of points. The menus and submenus are:

Point

Tap where you want the point to be and press Enter ≈.

Keyboard shortcut: EEX Sto▸ P

Point On

Tap the object where you want the new point to be and press Enter. If you select a point that has been placed on an object and then move that point, the point will be constrained to the object on which it was placed. For example, a point placed on a circle will remain on that circle regardless of how you move the point.

If there is no object where you tap, a point is created if you then press Enter.

Midpoint

Tap where you want one point to be and press Enter. Tap where you want the other point to be and press Enter. A point is automatically created midway between those two points.

If you choose an object first—such as a segment—choosing the Midpoint tool and pressing Enter adds a point midway between the ends of that object. (In he case of a circle, the midpoint is created at the circle's center.)

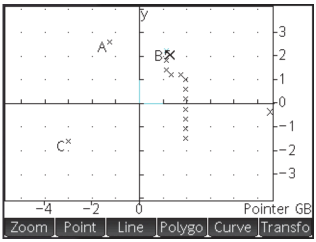
Intersection

Tap one of the two intersecting objects and press Enter. Tap the other object and press Enter. A point is created at one of the points of intersection.

Keyboard shortcut: TAN

More

Trace



Displays a list of points for you to choose the one you want to trace. If you subsequently move that point, a trace line is drawn on the screen to show its path. In the example at the right, point B was chosen to be traced. When that point was moved—up and to the left—a path of its movement was created.

Trace creates an entry in Symbolic view. In the example above, the entry is `Trace(GB)`.

Stop Trace

Turns off tracing and deletes the definition of the trace point from Symbolic view. If more than one point is being traced, a menu of trace points appears so that you can choose which one to untrace.

Untrace does not erase any existing trace lines. It merely prevents any further tracing should the point be moved again.

Erase Trace

Erases all trace lines, but leaves the definition of the trace points in Symbolic view. While a Trace definition is still in Symbolic view, if you move the point again, a new trace line is created.

Center

Tap a circle and press Enter.

Element 0 .. 1

???????????

Intersections

Tap one object and press Enter. Tap another object and press Enter. Each point of intersection is labeled (and labeled) identically. Note that an intersections object is created in Symbolic view even if the two objects selected do not intersect.

Random pts

Displays a palette for you to choose to add 1, 2, 3, or 4 points. The points are placed randomly.

Line

Segment

Tap where you want one endpoint to be and press Enter. Tap where you want the other endpoint to be and press Enter. A segment is drawn between the two end points.

Keyboard shortcut: 9

Ray

Tap where you want the endpoint to be and press Enter. Tap a point that you want the ray to pass through and press Enter. A ray is drawn from the first point and through the second point.

Line

Tap at a point you want the line to pass through and press Enter. Tap at another point you want the line to pass through and press Enter. A line is drawn the two points.

Keyboard shortcut: x^2

Vector

Tap where you want one endpoint to be and press Enter. Tap where you want the other endpoint to be and press Enter. A vector is drawn between the two end points.

Angle bisector

1 ∡ Bisector

Tap the point that is the vertex of the angle to be bisected (A) and press Enter. Tap another point (B) and press Enter. Tap a third point (C) and press Enter. A line is drawn through A bisecting the angle formed by $\overline{AB}$ and $\overline{AC}$.

Perpend-icular bisector

2 ⊥ Bisector

Tap one point on the line (*L*) you want to bisect and press Enter. Tap another point on *L* and press Enter. A line is drawn perpendicular to *L* and equidistant from the two points you tapped.

You can also draw a perpendicular bisector to a line that doesn't exist. Just tap and press Enter at one point and do the same at another point. A line is drawn perpendicular to the imaginary line between the two points and equidistant from both points.

If you are drawing a perpendicular bisector to a segment, choose the segment first and then select **Perp. Bisector** from the **Line** menu. The bisector is drawn immediately without you having to select any points. Just press Enter to save the bisector.

Parallel

3 ∥

Tap on a point (*P*) and press Enter. Tap on a line (*L*) and press Enter. A new line is draw parallel to *L* and passing through *P*.

Perpend-icular

4 ⊥

Tap on a point (*P*) and press Enter. Tap on a line (*L*) and press Enter. A new line is draw perpendicular to *L* and passing through *P*.

Tangent

Tap on a curve (*C*) and press Enter. Tap on a point (*P*) and press Enter. A one or more lines are drawn from *P* tangent to *C*.

Median

Tap on a vertex (A) and press Enter. tap on the line opposite the vertex and press Enter. A line is drawn through A that crosses segment $\overline{BC}$ equidistant from both endpoints.

Altitude

Tap on a vertex (A) and press Enter. tap on the line opposite the vertex and press Enter. A line is drawn through A that crosses segment $\overline{BC}$ at right angles.

Polygon

The **Polygon** menu provides tools for drawing various polygons.

Triangle

Tap at each vertex, pressing Enter after each tap.

Keyboard shortcut: ÷

Quadilateral

Tap at each vertex, pressing Enter after each tap.

Ngon

Polygon5

Produces a pentagon. Tap at each vertex, pressing Enter after each tap.

Polygon6

Produces a hexagon. Tap at each vertex, pressing Enter after each tap.

Hexagon

Produces a regular hexagon (that is, one with sides of equal length). Tap at each vertex, pressing Enter after each tap.

Special

Eq. triangle

1 Equilateral △

Produces an equilateral triangle. Tap at one vertex and press Enter. Tap at another vertex and press Enter. The location of the third vertex is automatically calculated and the triangle is drawn.

Square

Tap at one vertex and press Enter. Tap at another vertex and press Enter. Tap at a third vertex and press Enter. The location of the fourth vertex is automatically calculated and the square is drawn.

Parallel-ogram

Tap at one vertex and press Enter. Tap at another vertex and press Enter. Tap at a third vertex and press Enter. The location of the fourth vertex is automatically calculated and the parallelogram is drawn.

Curve

Circle

Tap at the center of the circle and press Enter. Tap at point on the circumference and press Enter. A circle is drawn about the center point with a radius equal to the distance between the two tapped points.

Keyboard shortcut: Units

You can also create a circle by first defining in Symbolic view. The syntax is `circle(GA,GB)` where `A` and `B` are two points. A circle is drawn in Plot view such that `A` and `B` are on the circumference.

Ellipse

Tap at one focus point and press Enter. Tap at the second focus point and press Enter. Tap at point on the circumference and press Enter.

Hyperbola

Tap at one focus point and press Enter. Tap at the second focus point and press Enter. Tap at point on one branch of the hyperbola and press Enter.

Parabola

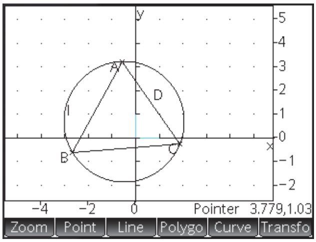
Tap at the focus point and press Enter. Tap either on a line (the directrix) or a point (the vertex) and press Enter.

Special

Circumcircle

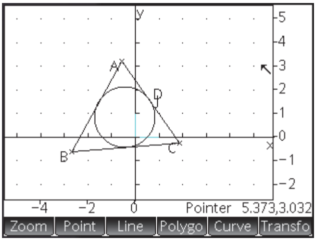
A circumcircle is the circle that passes through each of the triangle's three vertices, thus enclosing the triangle.

Tap at each vertex of the triangle, pressing Enter after each tap.



Incircle

An incircle is a circle that is tangent to each of a polygon's sides. The HP Prime can draw an incircle that is tangent to the sides of a triangle.

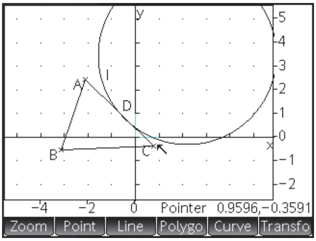


Tap at each vertex of the triangle, pressing Enter after each tap.

Excircle

If you extend two sides of a triangle in the direction opposite their common vertex and then draw a circle tangent both to these lines and to the third side of the triangle, you have an excircle.

Tap at each vertex of the triangle, pressing Enter after each tap.



The excircle is drawn tangent to the side defined by the last two vertices tapped. In the example at the right, the last two vertices tapped were A and C (or C and A). Thus the excircle is drawn tangent to the segment $\overline{AC}$.

Locus

???????????

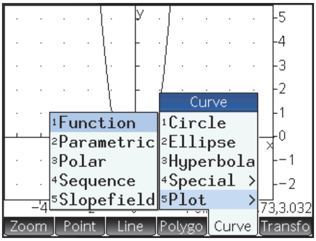
Plot

You can plot expressions of the following types in Plot view:

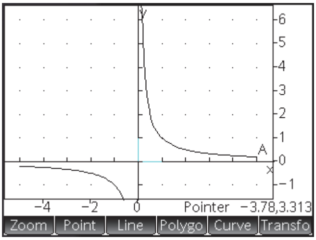
- Function
- Parametric
- Polar
- Sequence
- Slopefield

Tap Curve, select **Plot**, and then the type of expression you want to plot. The entry line is enabled for you to define the expression.

Note that the variables you specify for an expression must be in lowercase.



In this example, **Function** has been selected as the plot type and the graph of y = 1/ x is plotted.



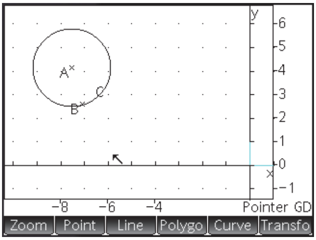
Geometric transformations

The **Transform** menu—displayed by tapping Transfor —provides numerous tools for you to transform a geometric object in Plot view.

Translation

Translation is moving each point of an abject the same distance and in the sam direction. You create a vector to indicate the distance and direction of the translation, choose the object to be translated, and copy of the object to moved in line with the vector.

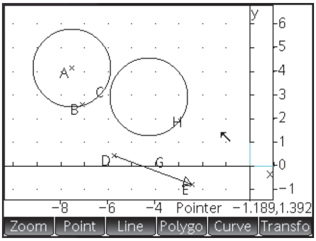
Suppose you want to move circle B at the right down a little and to the right:



1. Tap Line and select **Vector**.
2. Draw a vector in the direction you want to move the circle and of the same length as move you intend. (If you need help, see “Vector” on page 144.)
3. Tap Transfor.
4. Tap the vector and press Enter.

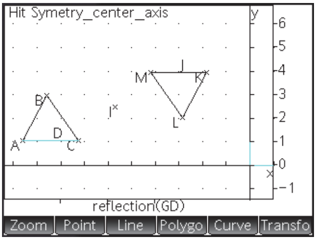
5. Tap the object to be moved and press Enter.

   The object is moved the same length as the vector and in the same direction. The original object is left in place.



Reflection

Reflection is a transformation in which a copy of an object is made and every point on the new object is the same distance from a symmetry axis (or mirror line) as the original point. In the example at the right, the original triangle D is reflected an imaginary symmetry axis that passes through point I.

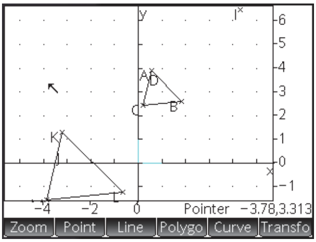


1. Tap Transfor and select **Reflection**.
2. Tap a point that will be in the symmetry axis (that is, mirror line) and press Enter.
3. Tap the object that is to be reflected across the symmetry axis and press Enter. The object is reflected across the symmetry axis defined by the point created at step 2.

Dilation

Dilation is a transformation where an object is enlarged or reduced by a given factor around a given center point. The factor is sometimes referred to as the homothetic ratio (or scale factor) and the center point is called the homothetic center (or center of dilation).

 the illustration at the right, the scale factor is 2 and the center of dilation is indicated by a point near the top right of the screen (named *I*). Each point on the new triangle is in line with its corresponding point on the original triangle and point *I*. Further, the distance from point *I*



to each new point will be twice the distance to the original point (since the scale factor is 2).

1. Tap Transfor and select **Dilation**.
2. Tap the point that is to be the center of dilation and press Enter.
3. Enter the homothetic ratio (that is, the scale factor) and press Enter.
4. Tap the object that is to be dilated and press Enter.

Rotation

Rotates a specified object about a specified point a specified number of degrees or radians.

[Not in Plot view, but available in Symbolic view. Broken as at May 18.]

More

Projection

Creates an projection of the points on one object onto another object. The projection is orthogonal, that is, each projected point meets the object onto which it is projected at right angles.

Broken as at 18 May

1. Tap Transfor and select **Projection**.
2. Tap the object onto which points are to be projected and press Enter.
3. Tap the object that is to projected and press Enter.

   Note the new points added to the target object.

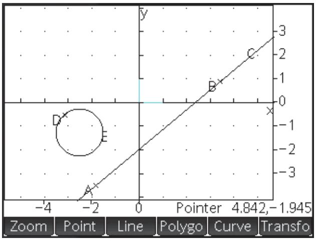
Inversion

Creates an inversion circle based on a specified center point, inversion ratio, and an inversion point on a line.

1. Tap Transfor and select **Inversion**.
2. Tap the point that is to be the center (C) of the inversion circle and press Enter.

3. Enter the inversion ratio (r) and press Enter.
4. Tap on a line where you want the inversion point (B) to be and press Enter.

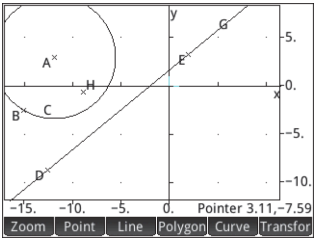
   In the example at the right, the inversion ratio is 6 and the inversion point was a point tapped on line AB. Note that the center point and inversion point are not created as separate points.



Reciprocation To create a point that is the reciprocation of another point (or a line) with respect to a circle:

1. Tap Transfor and select **Reciprocation**.
2. Tap the circle and press Enter.
3. . Tap the point or line that is to generate the reciprocation point and press Enter.

   In the example at the right, point H is the reciprocation of line G on circle C.



Geometry functions and commands

The list of geometry-specific functions and commands in this section covers those that can be found by tapping Cmds in both Symbolic and Numeric view and those that are only available from the Catlg menu.

The sample syntax provided has been simplified. Geometric objects are referred to by a single uppercase character (such as A, B,C and so on). However, calculations referring to geometric objects—in the Numeric view of the Geometry app and in the CAS—must use the G-prefixed name given for it in Symbolic view. For example:

`altitude(A,B,C)` is the simplified form given in this section `altitude(GA,GB,GC)` is the form you need to use in calculations

Further, in many cases the specified parameters in the syntax below—A, B, C etc.—can be the name of a point (such as GA) or a complex number representing a point. Thus `angle(A,B,C)` could be:

- `angle(GP,GR,GB)`
- `angle(3+2i,1−2i,5+i)` or
- a combination of named points and points defined by a complex number, as in `angle(GP,i1−2i,i)`.

Symbolic view: Cmds menu

Point

barycenter

barycenter([point1,coeff1],...) draws the barycenter of point1 with weight coeff1...

```
barycenter([Pnt,Real],[Pnt,Real],[Pnt,Real])
```

center

Gives the coordinates of the center of circle A.

```
center(A)
```

division_point

Returns the point M such that (z-a)=k*(z-b) and z=affix of M (MA=k*MB).

```
division_point(Pnt or Cplx(a),Pnt or
Cplx(b),Cplx(k))
```

element

Shows a point chosen on a curve or a real chosen in an interval

```
element((Curve or Real_interval),[Val])
```

inter

With 2 arguments gives the intersection of 2 curves or surfaces as a vector. If a third argument is given, the intersection returned is the one closest to that argument.

```
inter(Curve,Curve,[Pnt])
```

isobarycenter

isobarycenter(A,B,C,…) draws the isobarycenter of the n points A,B,C,…

midpoint

midpoint(A,B) draws the midpoint of the segment AB

```
midpoint((Pnt or Cplx),(Pnt or Cplx))
```

orthocenter

Shows the orthocenter of a triangle or of the triangle made with 3 points.

```
orthocenter((Pnt or Cplx),(Pnt or Cplx),(Pnt
or Cplx))
```

point

A:=point(za) (resp A:=point([a,b,c])) draws a point of affix za (resp of coordinates (a,b,c)) with the legend A

```
point(Cplx(za)||Vect)
```

point2d

Defines at random, the coordinates (between -5 and +5) of the 2-d points given as argument.

```
point2d(SeqVar(A,B,C...))
```

trace

Turns on tracing of the specified point.

Line

DrawSlp

Draws a line with slope m, going through the point (a, b).

```
DrawSlp(Real(a),Real(b),Real(m))
```

LineTan

Draws the tangent to y=f(x) at x=a.

```
LineTan(Expr(f(x)),[Var],Expr(a))
```

altitude

Draws a line through A that crosses segment $\overline{BC}$ at right angles.

```
altitude(A,B,C)
```

bisector

Draws the bisector of the angle (AB,AC) given by 3 points A,B,C.

```
bisector((Pnt(A) or Cplx),(Pnt(B) or
Cplx),(Pnt(C) or Cplx))
```

exbisector

Draws the exterior bisector of the angle (AB,AC) given by 3 points A,B,C.

```
exbisector((Pnt(A) or Cplx),(Pnt(B) or
Cplx),(Pnt(C) or Cplx))
```

half_line

half_line(A,B) draws the half-line AB with A as origin

```
half_line((Pnt or Cplx),(Pnt or Cplx))
```

line

line(A,B) or line(a*x+b*y+c=0) or line(a*x+b*y+c*z+d=0,aa*x+bb*y+cc*z+dd=0) draws the line AB in the plane or in the 3D space. line(A,slope=m) draws the line going through A with slope m or of equation the argument in the plane or in 3D space.

```
line(Pnt||Cplx||Eq,[Pnt||slope||Var])
```

median_line

median_line(A,B,C) draws the median-line through A of the triangle ABC

```
median_line((Pnt or Cplx),(Pnt or Cplx),(Pnt
or Cplx))
```

parallel

parallel(A,D) (resp parallel(A,P) or parallel(A,D,DD)) draws the line (resp plane) through A parallel to the line D (resp parallel to the plane P or to the lines D,DD) and, parallel(d,D) draws the plane through d parallel to the line D.

```
parallel(Pnt or Line,Line or Plan,[Line])
```

perpen_bisector

perpen_bisector(A,B) draws the bisection (line or plane) of the segment AB.

```
perpen_bisector((Pnt or Cplx),(Pnt or Cplx))
```

perpendicular

perpendicular(A,line(B,C)) or perpendicular(A,B,C) draws the orthogonal line of line BC through A and perpendicular(d,plane(B,C,D)) draws the orthogonal plane of plane(B,C,D) through the line d.

```
perpendicular((Pnt or Line),(Line or Plan))
```

segment

segment(A,B) draws the segment AB

```
segment((Pnt or Cplx),(Pnt or
Cplx),[Var],[Var])
```

tangent

tangent(C,A) draws the tangents (line or plane) to C through A.

```
tangent(Curve(C),Pnt(A))
```

Polygon

equilateral_triangle

equilateral_triangle(A,B) (resp equilateral_triangle(A,B,P)) draws the direct equilateral triangle ABC of side AB (resp in the half-plane ABP).

```
equilateral_triangle((Pnt(A) or Cplx),(Pnt(B)
or Cplx),[Pnt(P)],[Var(C)])
```

hexagon

Returns and draws the hexagon of side AB (ABCDEF is direct) (in the plane ABP.)

```
hexagon(Pnt(A)||Cplx,Pnt(B)||Cplx,[Pnt(P)],[V
ar(C)],[Var(D)],[Var(E)],[Var(F)])
```

isosceles_triangle

Draws the isosceles triangle ABC AB=AC and angle(AB,AC)=t (or in the plane ABP angle(AB,AC)=angle(AB,AP) or angle(AB,AC)=t).

```
isosceles_triangle((Pnt(A) or Cplx),(Pnt(B) or
Cplx),(Angle(t) or Pnt(P) or
Lst(P,t)),[Var(C)] )
```

isopolygon

Draws a regular polygon having abs(n) vertices, given by 2 vertices (or 2 vertices and 1 point of the plane) if n>0 and by its center and 1 vertex (or its center, 1 vertex and 1 point of the plane) if n<0.

```
isopolygon(Pnt,Pnt,[Pnt],Intg(n))
```

parallelogram

Returns and draws the parallelogram ABCD such as vector(AB)+vector(AD)=vector(AC).

```
parallelogram(Pnt(A)||Cplx,Pnt(B)||Cplx,Pnt(C
)||Cplx,[Var(D)] )
```

polygon

Returns and draws the polygon where its vertices are the element of l.

```
polygon(LstPnt||LstCplx)
```

quadrilateral

Returns and draws the quadrilateral ABCD.

```
quadrilateral(Pnt(A)||Cplx,Pnt(B)||Cplx,Pnt(C
)||Cplx,Pnt(D)||Cplx)
```

rectangle

Returns and draws the rectangle ABCD, AD=k*AB if k>0 ABCD is direct else indirect (in the plane ABP AD=AP or AD=k*AB).

```
rectangle(Pnt(A)||Cplx,Pnt(B)||Cplx,Real(k)||
Pnt(P)||Lst(P,k),[Var(D)],[Var(C)])
```

rhombus

Returns and draws the rhombus ABCD such as the angle (AB,AD)=a (or in the plane ABP angle(AB,AD)=angle(AB,AP) or such that angle(AB,AD)=a).

```
rhombus(Pnt(A)||Cplx,Pnt(B)||Cplx,Angle(a)||P
nt(P)||Lst(P,a)),[Var(C)],[Var(D)])
```

right_triangle

Draws the A_rectangular triangle ABC with AC=k*AB (or in the plane ABP AC=AP or AC=k*AB).

```
right_triangle((Pnt(A) or Cplx),(Pnt(B) or
Cplx),(Real(k) or Pnt(P) or
Lst(P,k)),[Var(C)])
```

square

Returns and draws the square of side AB (ABCD is direct) (in the plane ABP.

```
square((Pnt(A) or Cplx),(Pnt(B) or
Cplx),[Pnt(P),Var(C),Var(D)])
```

triangle

triangle(A,B,C) draws the triangle ABC

```
triangle((Pnt or Cplx),(Pnt or Cplx),(Pnt or
Cplx))
```

Curve

Function

Defines a function plot.

```
plotfunc(Expr)
```

circle

Define for 2-d a circle with a diameter (arg2=Point) or with center and radius (arg2=Complex, abs(arg2)=radius)

[or the arc AB, A angle a, B angle b (arg1+arg2=angle 0)] or by its equation and for 3-d with a diameter and a third point

```
circle((Pnt or Cplx),(Pnt(arg2) or
Cplx(arg2)),[Real(a)],[Real(b)],[Var(A)],[Var
(B)])
```

circumcircle

circumcircle(A,B,C)=circumcircle of the triangle ABC.

```
circumcircle((Pnt or Cplx),(Pnt or Cplx),((Pnt
or Cplx))
```

conic

Defines a conic by its equation with x,y as default variables and draws it.

```
conic(Expr,[LstVar])
```

ellipse

ellipse(F1,F2,M)=ellipse focus F1,F2 through M or such as MF1+MF2=2*a (geo2d) and ellipse(p(x,y)) draws the conic if deg(p)=2.

```
ellipse(Pnt(F1),Pnt(F2),(Pnt(M) or Real(a)) y
ellipse(p(x,y))=conic si deg(p)=2.)
```

excircle

excircle(A,B,C) draws the A-excircle of the ABC triangle.

```
excircle((Pnt or Cplx),(Pnt or Cplx),(Pnt or
Cplx))
```

hyperbola

hyperbola(F1,F2,M)=hyperbola focus F1,F2 through M or (|MF1-MF2|=2*a geo2d) and hyperbola(p(x,y)) draws the conic if deg(p)=2.

```
hyperbola(Focus(F1),Focus(F2),(Pnt(M) or
Real(a)))
```

incircle

incircle(A,B,C) draws the incircle of the ABC triangle.

```
incircle((Pnt or Cplx),(Pnt or Cplx),(Pnt or
Cplx))
```

locus

locus(M,A) draws the locus of M (or locus(d,A) draws the envelope of d) when A:=element(C) (C is a curve). The example instructions below must be written in a geometric level on different lines.

```
locus(Pnt,Elem)
```

parabola

parabola(F,A)=focus F, top A (in the plane ABP) or (parabola(A,c) of equa. y=yA+c*(x-xA)^2 c=1/(2*p) and FA=p/2 geo2d) and parabola(P(x,y)) draws the conic if deg(P)=2.

```
parabola(Pnt(F)||Pnt(xA+i*yA),Pnt(A)||Real(c)
,
[Pnt(P)])
```

Transform

homothety

homothety(C,k,A)=point A1 such as vect(C,A1)=k*vect(C,A) i.e in 2-d it is the similarity center C, coeff abs(k) and angle arg(k).

```
homothety(Pnt(C),Real(k),Pnt(A))
```

inversion

inversion(C,k,A)=point A1 such as A1 on line(C,A) and mes_alg(CA1*CA)=k

```
inversion(Pnt(C),Real(k),Pnt(A))
```

```
isobarycenter((Pnt or Cplx),(Pnt or Cplx),(Pnt
or Cplx))
```

projection

projection(C,A) is the orthogonal projection of A on the curve C

```
projection(Curve,Pnt)
```

reflection

reflection(D,C) (or reflection(A,C))=symmetrical of C in the symmetry-line D (or sym-point A)

```
reflection((Pnt(A) or Line(D)),(Pnt(C) or
Curve(C)))
```

rotation

rotation(B,a1,A)(resp rotation(d,a1,A)) is the transformation of A by rotation of center B (resp of axis d) and of angle a1.

```
rotation((Pnt(B) or Cplx or
Dr3),Angle(a1),(Pnt(A) or Curve))
```

similarity

similarity(B,k,a1,A)=transformation of A in the similarity (center B or axis d, coeff k,angle a1) (or also homothety(B,k*exp(i*a1),A)).

```
similarity(Pnt or Dr3,Real,Angle,Pnt)
```

translation

translation(B-A,C) (resp translation([a,b,c],C)) is the translation of C in the translation of vector AB (resp [a,b,c]).

```
translation(Vect, Pnt(C))
```

Numeric view: Cmds menu

Measure

abscissa

The *x* coordinate of a point or the *x* length of a vector.

```
abscissa(A) or abscissa(vector)
```

affix

Gives the affix of a point (that is, its coordinates expressed as a complex number) or the affix of a vector.

```
affix(A) or affix(vector)
```

angle

Calculates the angle made by $\overline{AB}$ and $\overline{AC}$.

```
angle(A,B,C)
```

arcLen

Returns the length of the arc of the curve defined by y=Xpr (or by x=Xpr1,y=Xpr2) when the parameter values are between a and b.

```
arcLen(Expr(Xpr) or
Lst([Xpr1,Xpr2]),Var,Real(a),Real(b))
```

area

Algebraic area of a circle or polygon or of the area below a curve, optionally with a quadrature method (trapezoid, left_rectangle, right_rectangle, middle_point, simpson, rombergt, rombergm).

```
area(Polygon)
```
or
```
area(Expr,x=a..b,[n],[Method])
```

coordinates

Returns the list (resp matrix) of the abscissa and of the ordinate of a point or a vector (resp of points or vectors).

```
coordinates(Pnt or Cplx or Vect)
```

distance

Calculates the distance between 2 points or a point and a curve

```
distance((Pnt or Cplx),(Pnt or Cplx or Curve))
```

distance2

Calculates the square of the distance between 2 points or a point and a curve

```
distance2((Pnt or Cplx),(Pnt or Cplx or
Curve))
```

distanceat

distanceat(A,B,z0) displays at point(z0), with a legend, the distance between 2 geometrical objects

```
distanceat(GeoObj(A),GeoObj(B),(Pnt or Cplx))
```

distanceatraw

distanceatraw(A,B,z0) displays at the point(z0), the distance between 2 geometrical objects.

```
distanceatraw(GeoObj(A),GeoObj(B),(Pnt or
Cplx(z0)))
```

equation

equation returns the cartesian equation of a curve

```
equation(GeoObj, VectParam)
```

extract_measure

extract_measure gives as answer the value calculated by the argument.

```
extract_measure(Var)
```

ordinate

Returns the ordinate of a point or a vector.

```
ordinate(Pnt or Vect)
```

parameq

parameq(C) returns the complex number=parametric equation of the curve C

```
parameq(GeoObj )
```

perimeter

Perimeter of a polygon (e.g. triangle, square, ...)

```
perimeter(Polygon)
```

radius

radius(C) gives the radius of the circle C

```
radius(Crcle)
```

Test

is_collinear

Returns 1 if the points are aligned,2 if the points are the same and 0 otherwise.

```
is_collinear(LstPnt)
```

is_concyclic

Returns 1 if the points are on a circle and 0 otherwise.

```
is_concyclic(LstPnt)
```

is_conjugate

Returns 1 if the 3 (resp 4) arguments are conjugated toward a circle (resp 2 lines) and 0 otherwise.

```
is_conjugate(Crcle||Line,Pnt||Line,Pnt||Line,
[Pnt||Line])
```

is_coplanar

Test if 4 points are in the same plane.

```
is_coplanar(Pnt,Pnt,Pnt,Pnt)
```

is_element

Returns 1 if the point is on the geometric object and 0 otherwise.

```
is_element(Pnt,GeoObj)
```

is_equilateral

Returns 1 if the 3 points (or the object) build an equilateral triangle and 0 otherwise.

```
is_equilateral(Pnt||Cplx,Pnt||Cplx,Pnt||Cplx)
```

is_isoceles

Returns 1, 2 or 3 if the 3 points (or the object) build an isosceles triangle with vertices 1, 2, or 3, returns 4 if the 3 points (or the object) build an equilateral triangle and 0 otherwise.

```
is_isosceles(Pnt or Cplx,Pnt or Cplx,Pnt or
Cplx)
```

is_orthogonal

Returns 1 if the 2 circles are orthogonal (orthogonal tangents at a point of intersection) or if the 2 lines are orthogonal and 0 otherwise.

```
is_orthogonal(Line||Crcle,Line||Crcle)
```

is_parallel

Returns 1 if 2 lines are parallel and 0 otherwise.

is_parallel(Line or Plan ,Line or Plan)

is_parallelogram

Returns 1, 2, 3 or 4 if the 4 points (or the object) build a parallelogram, (2 for a rhombus, 3 for a rectangle, 4 for a square) and 0 otherwise.

```
is_parallelogram(Pnt or Cplx,Pnt or Cplx,Pnt
or Cplx,Pnt or Cplx)
```

is_perpendicular

Returns 1 if 2 lines are perpendicular

```
is_perpendicular(Line or Plan,Line or Plan)
```

is_rectangle

Returns 1, 2 or 3 if the 3 points (or the object) build a rectangular triangle with vertex 1, 2 or 3 and 0 otherwise [or 1 if the 4 points (or the object) build a rectangle, 2 if the 4 points (or the object) build a square and 0 otherwise].

```
is_rectangle(Pnt||Cplx,Pnt||Cplx,Pnt||Cplx,[P
nt||Cplx])
```

is_square

Returns 1 if the 4 points build a square and 0 otherwise.

```
is_square(Pnt,Pnt,Pnt,Pnt)
```

Other Geometry functions

The following functions are not available from a menu in the Geometry app, but are available from the Catlg menu.

angleat

angleat(A,B,C,z0) displays at point(z0) the value of the measure of the angle made by $\overline{AB}$ and $\overline{AC}$ along with a legend.

```
angleat(A,B,C,z0)
```

angleatraw

Same as `angleat` but without providing a legend.

areaat

Displays at point (z0), with a legend, algebraic area of a circle or of a (star) polygon (e.g. triangle, square, ...)

```
areaat(Polygon, Pnt||Cplx(z0))
```

areaatraw

Displays at point(z0), algebraic area of a circle or of a (star) polygon (e.g. triangle, square, ...)

```
areaatraw(Polygone, Pnt||Cplx(z0))
```

common_perpendicular

Draws the common perpendicular of the lines D1 and D2.

```
common_perpendicular(Line(D1),Line(D2))
```

cone

Draws a cone with vertex A, direction v, and with half-angle t [and with altitude h and -h].

```
cone(Pnt(A),Vect(v),Real(t),[Real(h)])
```

convexhull

Convex hull of a list of 2-d points

```
convexhull(Lst)
```

cube

Draws the direct cube with vertices A,B with a face in the plan (A,B,C).

```
cube(Pnt(A),Pnt(B),Pnt(C))
```

cylinder

Draws a cylinder with axis (A,v), with radius r [and with altitude h].

```
cylinder(Pnt(A),Vect(v),Real(r),[Real(h)])
```

display

Draws an geometrical object with color (black=0 red=1 green=2 yellow=3 blue=4). If object is closed, object can be *filled*. Line_width_n (0<n<8) is for the width of the line and dash_line is for dotted line.

`display(circle(0,1),2)` returns a green circle of radius 1.

`display(square(0,5),filled+blue+line_width_6)` returns a blue square of sides 5, filled with blue and a of line width of 6.

faces

Returns the list of the faces (1 face=matrix(n,3) where the n rows are the n vertices of the face) of the polyhedron P.

```
faces(Polygon or Polyedr(P))
```

half_cone

Draws a half-cone with vertex A, direction v and with half_angle=t [and with altitude h].

```
half_cone(Pnt(A),Vect(v),Real(t),[Real(h)])
```

harmonic_conjugate

Returns the harmonic conjugate of 3 points or of 3 parallel or concurrent lines or the line of conjugates of a point in respect to 2 lines.

```
harmonic_conjugate(Line or Pnt,Line or
Pnt,Line or Pnt)
```

harmonic_division

Returns the 4 points (resp lines) and affects the last argument, such as the 4 points (resp lines) are in a harmonic division.

```
harmonic_division(Pnt or Line,Pnt or Line,Pnt
or Line,Var)
```

icosahedron

Draws an icosahedron with center A, vertex B and such that the plane ABC contains one vertex among the 5 nearest vertices from B.

```
icosahedron(Pnt(A),Pnt(B),Pnt(C))
```

is_harmonic

Returns 1 if the 4 points are in a harmonic division and 0 otherwise.

```
is_harmonic(Pnt or Cplx,Pnt or Cplx,Pnt or
Cplx,Pnt or Cplx)
```

is_harmonic_circle_bundle

Returns 1 if the circles build a beam, 2 if they have the same center, 3 if they are the same and 0 otherwise.

```
is_harmonic_circle_bundle(Lst(Crcle))
```

is_harmonic_line_bundle

Returns 1 if the lines have a common point, 2 if they are parallels, 3 if they are the same and 0 otherwise.

```
is_harmonic_line_bundle(Lst(Line))
```

is_rhombus

Returns 1 or 2 if the 4 points (or the object) build a rhombus (2 for a square) and 0 otherwise.

```
is_rhombus(Pnt or Cplx,Pnt or Cplx,Pnt or
Cplx,Pnt or Cplx)
```

length

Returns the size of a list, a string or a sequence

```
length(Lst or Str or Seq)
```

LineHorz

Draws the horizontal line y=a.

```
LineHorz(A)
```

line_segments

Returns the list of the line_segments (1 line=segment) of the polyhedron P

```
line_segments(Polygon or Polyedr(P))
```

LineVert

Draws the vertical line x=a.

```
LineVert(Expr(a))
```

octahedron

Draws an octahedron with center A, vertex B and such that the plane ABC contains 4 vertices.

```
octahedron(Pnt(A),Pnt(B),Pnt(C))
```

open_polygon

Returns and draws the polygonal line where its vertices are the element of l.

```
open_polygon(LstPnt||LstCplx)
```

orthogonal

orthogonal(A,line(B,C)) draws the orthogonal plane of line BC through A and orthogonal(A,plane(B,C,D)) draws the orthogonal line of plan(B,C,D) through A.

```
orthogonal((Pnt),(Line or Plan) )
```

parallelepiped

Draws a parallelepiped with sides AB,AC,AD (the faces are parallelograms).

```
parallelepiped(Pnt(A),Pnt(B),Pnt(C),Pnt(D))
```

perimeterat

Displays at point(z0), with a legend, the perimeter of a circle or of a polygon (e.g. triangle, square, ...)

```
perimeterat(Polygon, Pnt||Cplx(z0))
```

perimeteratraw

Displays at point(z0), the perimeter of a circle or of a polygon (e.g. triangle, square, ...)

```
perimeteratraw(Polygon, Pnt||Cplx(z0))
```

plane

plane(A,B,C) or plane(A,line(B,C)) (resp plane(a*x+b*y+c*z+d=0)) draws the plane ABC (resp of equation a*x+b*y+c*z+d=0) in the 3-D space.

```
plane(Pnt or Eq, [Pnt or Line],[Pnt])
```

polar

Returns the line of the conjugated points of A with respect to the circle.

```
polar(Crcle,Pnt or Cplxe(A))
```

polar_coordinates

Returns the list of the norm and of the argument of the affix of a point (for 2-D) or of a complex number or of the the list of rectangular coordinates.

```
polar_coordinates(Pnt or Cplx or LstRectCoord)
```

pole

Returns the point having the line as polar with respect to the circle.

```
pole(Crcle,Line)
```

polyhedron

Draws a convex polyhedron with vertices among the arguments.

```
polyhedron(SeqPnt(A,B,C...))
```

powerpc

Returns the real number d^2-R^2 (d=distance between point and center, R=radius) .

```
powerpc(Circle,Pnt or Cplx)
```

prism

Draws a prism with plane base ABCD...and with edges parallel to AA1 (the faces are parallelograms).

```
prism(LstPnt([A,B,C,D]),Pnt(A1))
```

pyramid

Draws the regular direct pyramid ABCD with vertices A,B and a face in the plan (A,B,C) when there are 3 arguments, and the pyramid ABCD when there are 4 arguments.

```
pyramid(Pnt(A),Pnt(B),Pnt(C),[Pnt(D)])
```

radical_axis

Returns the line of points with same powerpc with respect to the 2 circles.

```
radical_axis(Crcle,Crcle)
```

reciprocation

Returns the list where a point (resp a line) are replaced with its polar (resp pole), with respect to the circle C.

```
reciprocation(Crcle,Lst(Pnt,Line))
```

single_inter

Gives one of the intersections of 2 curves or surfaces (or the intersection near A or not in L).

```
single_inter(Curve,Curve,[Pnt(A)||LstPnt(L)])
```

slopeat

slopeat(d,z0) displays at the point(z0), with a legend, the value of the slope of the line or segment d.

```
slopeat(Line, Pnt||Cplx(z0))
```

slopeatraw

slopeatraw(d,z0) displays at point(z0), the value of the slope of the line or segment d.

```
slopeatraw(Line, Pnt||Cplx(z0))
```

sphere

sphere(A,B) (resp sphere(A,r)) draws the sphere of diameter AB (resp center A and radius r) in the space 3-D.

```
sphere((Pnt or Vect),(Pnt or Real))
```

vector

Defines a vector(origin is 0 if 1 arg) with two points or two components or two affix (for 2-D) or with a point and a vector or with a point (its extremity and its origin is [0,0,0]).

```
vector(Pnt,Pnt || Pnt,Vect)
```

vertices

Returns the list of the vertices of the polygon or polyhedron P.

```
vertices(Polygon or Polyedr(P))
```

vertices_abca

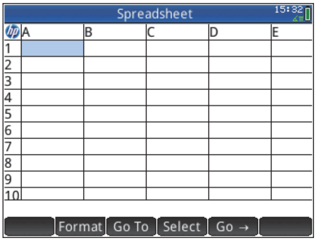
Returns the closed list [A,B,...A] of the vertices of the polygon or polyhedron P.

```
vertices_abca(Polygon or Polyedr(P)
```

8

Spreadsheet

The Spreadsheet app provides a grid of cells for you to enter content (such as numbers, text, expressions, and so on) and to perform certain operations on what you enter.



To open the Spreadsheet app, press Apps and select **Spreadsheet**.

You can create any number of customized spreadsheets, each with its own name (see “Creating an app” on page 97). You open a customized spreadsheet in the same way: by pressing Apps and selecting the particular spreadsheet.

The maximum size of any one spreadsheet is 10,000 rows by 676 columns.

The app opens in Numeric view. There is no Plot or Symbolic view. There is a Symbolic Setup view (Shift Symb) that enables you to override certain system-wide settings. (See “Common operations in Symbolic Setup view” on page 76.)

Getting started with the Spreadsheet app

Suppose you have a stall at a weekend market. You sell furniture on consignment for their owners, taking a 10% commission for yourself. You have to pay the landowner $100 a day to set up your stall and you will keep the stall open until you have made $250 for yourself.

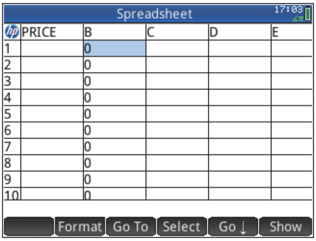
1. Open the Spreadsheet app:

   Apps and select `Spreadsheet`.

2. Select column `A`. Either tap on `A` or use the cursor keys to highlight the `A` cell (that is, the heading of the `A` column).

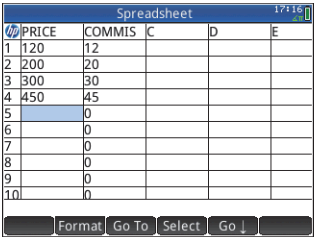
3. Enter `PRICE` and tap Name. You have named the entire first column `PRICE`.
4. Select column `B`. Either tap on `B` or use the cursor keys to highlight the `B` cell.
5. Enter a formula for your commission (being 10% of the price of each item sold):

   Shift = PRICE × 0.1 Enter

   Because you entered the formula in the heading of a column, it is automatically copied to every cell in that column. At the moment only 0 is shown, since there are no values in the `PRICE` column yet.
6. Once again select the header of column B.
7. Tap Format and select `Name`.
8. Type `COMMIS` and tap OK.

   Note that the heading of column `B` is now `COMMIS`.
9. It is always a good idea to check your formulas by entering some dummy values and noting if the result is as expected. Select cell `A1` and make sure that Go ↓ and not Go → is showing in the menu. (If not, tap the button.) This option means that your cursor automatically selects the cell immediately *below* the one you have just entered content into.
10. Add some values in the `PRICE` column and note the result in the `COMMIS` column. If the results do not look right, you can tap the `COMMIS` heading, tap Edit and fix the formula.

11. To delete the dummy values, select cell A1, tap Select, press ▼ until all the dummy values are selected, and then press Del.
12. Select cell C1.
13. Enter a label for your takings:

    Shift ≐ ALPHA " " TAKINGS Enter

    Notice that text strings, but not names, need to be enclosed within quotation marks.
14. Select cell D1.
15. Enter a formula to add up your takings:

    Shift ≐ SUM ( ) PRICE Enter

    You could have specified a range—such as A1:A100—but by specifying the name of the column, you can be sure that the sum will include all the entries in the column.
16. Select cell C3.
17. Enter a label for your total commission:

    Shift ≐ ALPHA " " TOTAL COMMIS Enter

    Note that the column is not wide enough for you to see the entire label in C3. We need to widen column C.
18. Select the heading cell for column C, tap Format and select **Column ↔**.

    An input form appears for you to specify the required width of the column.
19. Enter 100 and tap OK.

    You may have to experiment until you get the column width exactly as you want it. The value you enter will be the width of the column in pixels.
20. Select cell D3.
21. Enter a formula to add up your commission:

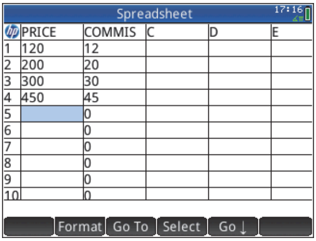
    Shift ≐ SUM ( ) COMMIS Enter

    Note that instead of entering SUM by hand, you could have chosen it from the Apps menu (one of the Toolbox menus).
22. Select cell C5.

23. Enter a label for your fixed costs:

Shift ≟ ALPHA 0 COSTS Enter

24. In cell `C5`, enter 100. This is what you have to pay the landowner for renting the space for your stall.



25. Enter the label `PROFIT` in cell `C7`.

26. In cell `D7`, enter a formula to calculate your profit:

Shift ≟ D3 − D5 Enter

You could also have named `D3` and `D5`—say, `TOTCOM` and `COSTS` respectively. Then the formula in `D7` could have been `=TOTCOM–COSTS`.

27. Enter the label `GOAL` in cell `E1`.

You can swipe the screen with a finger, or repeatedly press the cursor keys, to bring `E1` into view.

28. Enter 250 in cell `F1`.

This is the minimum profit would want to make on the day.

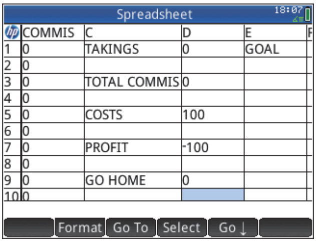
29. In cell `C9`, enter the label `GO HOME`.

30. In cell `D9`, enter:

Shift ≟ D7 ≥ F1 Enter

You can select ≥ from the relations palette (Shift 6).

What this formula does is place 0 in `D9` if you have not reached your goal profit, and 1 if you have. It provides a quick way for you to see when you have made enough profit and can go home.



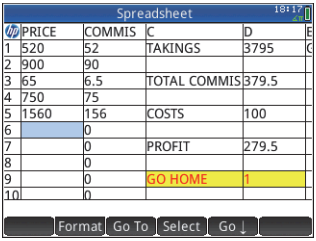
31. Select `C9` and `D9`.

You can select both cells with a finger drag, or by highlighting `C9`, selecting Select and pressing ▶.

32. Tap Format and select `Color`.
33. Choose a color for the contents of the selected cells.
34. Tap Format and select `Fill`.
35. Choose a color for the background of the selected cells.

    The most important cells in the spreadsheet will now stand out from the rest.

The spreadsheet is complete, but you may want to check all the formulas by adding some dummy data to the `PRICE` column. When the profit reaches 250, you should see the value in `D9` change from 0 to 1.


Spreadsheet 18:17

	PRICE	COMMIS	C	D	E
1	520	52	TAKINGS	3795	
2	900	90			
3	65	6.5	TOTAL COMMIS	379.5	
4	750	75			
5	1560	156	COSTS	100	
6		0			
7		0	PROFIT	279.5	
8		0			
9		0	GO HOME	1	
10		0			

Format Go To Select Go ↓

Basic operations

Navigation, selection and gestures

You can move about a spreadsheet by using the cursor keys, by swiping, or by tapping Go To and specifying the cell you want to move to.

You select a cell simply by moving to it. You can also select an entire column—by tapping the column letter—and select an entire row (by tapping the row number). You can also select the entire spreadsheet: just tap on the unnumbered cell at the top-left corner of the spreadsheet. (It has the HP logo in it.)

A block of cells can be selected by pressing down on a cell that will be a corner cell of the selection and, after a second, dragging your finger to the diagonally opposite cell. You can also select a block of cells by moving to a corner cell, tapping Select and using the cursor keys to move to the diagonally opposite cell. Tapping on Sel• or another cell deselects the selection.

Cell references

You can refer to the value of a cell in formulas as if it were a variable. A cell is referenced by its column and row coordinates, and references can be absolute or relative. An absolute reference is written as CR (where *C* is the column number and *R* the row number). Thus B7 is an absolute reference. In a formula it will always refer to the data in cell B7 wherever that formula, or a copy of it, is placed. On the other hand, B7 is a relative reference. It is based on the *relative position* of cells. Thus a formula in, say, B8 that references B7 will reference C7 instead of B7 if it is copied to C8.

Ranges of cells can also be specified, as in C6:E12, as can entire columns (E:E) or entire rows ($3:$5). Note that the alphabetic component of column names can be uppercase or lowercase except for columns g, l, m, and z. These must be in lowercase *if not preceded by $*. Thus cell B1 can be referred to as `B1,b1,$B$1` or `$b$1` whereas M1 can only be referred to as `m1`, `$m$1`, `or $M$1`. (G, L, M, and Z are names reserved for graphic objects, lists, matrices, and complex numbers.)

Cell naming

Cells, blocks of cells, rows, and columns can be named. The name can then be used in a formula. A named cell or block of cells is given a blue border.

Method 1 To name an *empty* cell, row, or column, go the cell, row header, or column header, enter a name and tap Name.

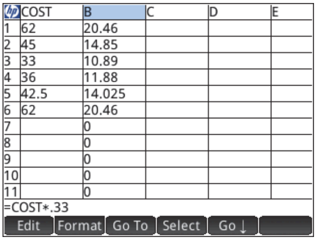
Method 2 To name a cell, block, row, or column—whether it is empty or not:

1. Select the cell, block, row, or column.
2. Tap Format and select `Name`.
3. Enter a name and tap OK.

Using names in calculations The name you give a cell or block of cells can be used in a formula. For example, if you name a cell `TOTAL`, you could enter in another cell the formula `=TOTAL*1.1`.

The following is a more complex example involving the naming of an entire column.

1. Select cell A (that is the header cell for column A).
2. Enter COST and tap Name.
3. Select cell B (that is the header cell for column B).
4. Enter Shift = COST*0.33 and tap OK.



5. Enter some values in column A and observe the calculated results in column B.

Entering content

You can enter content directly in the spreadsheet or import data from a statistics app.

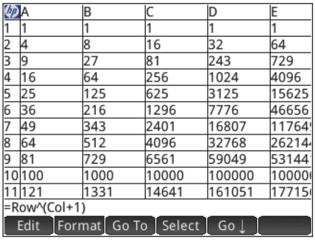
Direct entry

A cell can contain any valid calculator object: a real number (3.14), a complex number ($a + ib$), an integer (#1Ah), a list ({1, 2}), a matrix or vector([1, 2]), a string ("text"), a unit (2_m) or an expression (that is, a formula). Move to the cell you want to add content to and start entering the content as you would in Home view. Press Enter when you have finished. You can also enter content into a number of cells with a single entry. Just select the cells, enter the content—for example, =Row*3—and press Enter.

What you enter on the entry line is evaluated as soon as you press Enter, with the result placed in the cell or cells. However, if you want to retain the underlying formula, precede it with Shift =. For example, suppose that want to add cell A1 (which contains 7) to cell B2 (which contains 12). Entering A1 + B2 Enter in, say, A4 yields19, as does entering Shift = A1 + B2 in A5. However, if the value in A1 (or B2) changes, the value in A5 changes but not the value in A4. This is because the expression (or formula) was retained in A5. To see if a cell contains just the value shown in it or also an underlying formula that generates the value, move your cursor to the cell. The entry line shows a formula if there is one.

A single formula can add content to every cell in a column or row. For example, move to `C` (the heading cell for column C), enter [Shift] [=] `SIN(Row)` and press [Enter]. Each cell in the column is populated with the sine of the cell's row number. A similar process enables you to populate every cell in a row with the same formula. You can also add a formula once and have it apply to *every* cell in the spreadsheet. You do this by placing the formula in the cell at the top left (the cell with the HP logo in it). To see how this works, suppose you want to generate a table of powers (squares, cubes, and so on) starting with the squares:

1. Tap on the cell with the HP logo in it (at the top left corner). Alternatively, you can use the cursor keys to move to that cell (just as you can to select a column or row heading).



	A	B	C	D	E
1	1	1	1	1	1
2	4	8	16	32	64
3	9	27	81	243	729
4	16	64	256	1024	4096
5	25	125	625	3125	15625
6	36	216	1296	7776	46656
7	49	343	2401	16807	11764
8	64	512	4096	32768	26214
9	81	729	6561	59049	53144
10	100	1000	10000	100000	10000
11	121	1331	14641	161051	17715

=Row^(Col+1)

Edit Format Go To Select Go ↓

2. On the entry line type [Shift] [=] Row [x^y] [( )] Col [+] 1

   Note that `Row` and `Col` are built-in variables. They are placeholders for the row number and column number of the cell that has a formula containing them.

3. Tap [OK] or Press [Enter].

   Note that each column gives the *n*th power of the row number starting with the squares. Thus 9^5 is 59,049.

Import data

You can import data from the Statistics 1Var and Statistics 2Var apps (and from any app customized from a statistics app). In the procedure immediately below, dataset `D1` from the Statistics 1Var app is being imported.

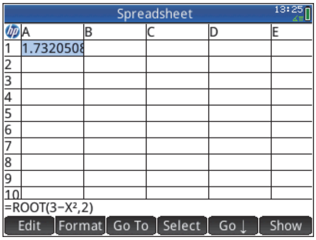
1. Select a cell.
2. Enter `Statistics_1Var.D1`.
3. Press [Enter].

The column is filled with the data from the statistics app, starting with the cell selected at step 1. Any data in that data will be overwritten by the data being imported.

You can also export data from the Spreadsheet app to a statistics app. See “Entering and editing statistical data” on page 191 for the general procedure. It can be used in both the Statistics 1Var and Statistics 2Var apps.

External functions

You can use in a formula any function available on the Math, CAS, App, User or Catlg menus (see chapter 20, “Functions and commands” on page 283). For example, to find the root of $3 - x^2$ closest to $x = 2$, you could enter in a cell



[Shift] [=] [ALPHA] [ALPHA] ROOT [ALPHA] [( )] 3 [−] [ALPHA] [x] [x²] [,] 2 [Enter]. The answer displayed is 1.732…

You could also have selected a function from a menu. For example:

1. Press [Shift] [=].
2. Press [Toolbox] and tap [CAS].
3. Select `Polynomial` > `Find Roots`.

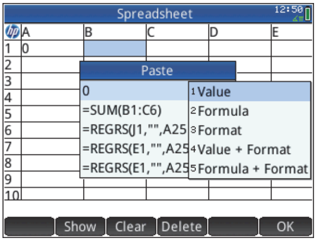
   Your entry line will now look like this: `=CAS.proot()`.
4. Enter the coefficients of the polynomial, in descending order, separating each with a comma:

   [+/−] 1 [,] 0 [,] 3
5. Press [Enter] to see the result: 1.732…

Note that the CAS prefix added to your function is to remind you that the calculation will be carried out by the CAS (and thus a symbolic result will be returned, if possible). You can also force a calculation to be handled by the CAS by tapping [CAS] in the spreadsheet.

There are additional spreadsheet functions that you can use (mostly related to finance and statistics calculations). See “Spreadsheet functions” on page 314.

Copy and paste

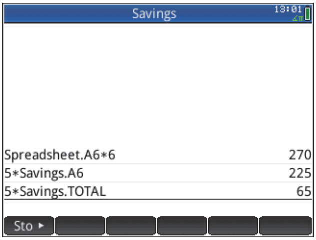


To copy one or more cells, select them and press Shift View Copy (Copy).

Move to the desired location and press (Shift Menu Paste (Paste).

You can choose to paste either the value, formula, format, both value and format, or both formula and format.

External references



You can refer to data in a spreadsheet from outside the Spreadsheet app by using the reference `SpreadsheetName.CR`. For example, in Home view you can refer to cell A6 in the built-in spreadsheet by entering `Spreadsheet.A6`. Thus the formula `6*Spreadsheet.A6` would multiply whatever value is currently in cell A6 in the built-in app by 6.

If you have created a customized spreadsheet called, say, **Savings**, you simply refer to it by its name, as in `5*Savings.A6`.

An external reference can also be to a named cell, as in `5*Savings.TOTAL`.

In the same way, you can also enter references to spreadsheet cells in the CAS.

If you are working outside a spreadsheet, you cannot refer to a cell by its absolute reference. Thus `Spreadsheet.$A$6` produces an error message.

Note that a reference to a spreadsheet name is case-sensitive.

Referencing variables

Any variable can be inserted in a spreadsheet cell. This includes Home variables, App variables, CAS variables and user variables.

Variables can be referenced or entered. For example, if you have assigned 10 to `P` in Home view, you could enter `=P*5` in a spreadsheet cell, press Enter and get `50`. If you subsequently changed the value of `P`, the value in that cell automatically changes to reflect the new value. This is an example of a *referenced* variable.

If you just wanted the current value of `P` and not have the value change if `P` changed, just enter `P` and press Enter. This is an example of an *entered* variable.

Variables given values in other apps can also be referenced in a spreadsheet. In chapter 12 we see how the Solve app can be used to solve equations. An example used is $V^2 = U^2 + 2AD$. You could have four cells in a spreadsheet with `=V`, `=U`, `=A`, and `=D` as formulas. As you experiment with different values for these variables in the Solve app, the entered and the calculated values are copied to the spreadsheet (where further manipulation could be done).

The variables from other apps includes the results of certain calculations. For example, if you have plotted a function in the Function app and calculated the signed area between two *x*-values, you can reference that value in a spreadsheet by pressing Vars, tapping App, and then selecting `Function` > `Results` > `SignedArea`.

Numerous system variables are also available. For example, you could enter Shift + Enter to get the last answer calculated in Home view. You could also enter Shift ÷ Shift + Enter to get the last answer calculated in Home view and have the value automatically updated as new calculations are made in Home view. (Note that this works only with the `Ans` from Home view, not the `Ans` from CAS view.)

All the variables available to you are listed on the variables menus, displayed by pressing Vars. A comprehensive list of these variables is provided in chapter 21, “Variables”, beginning on page 373.

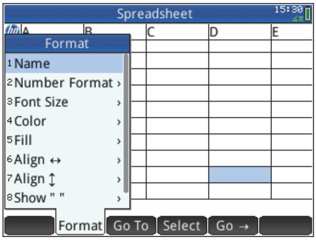
Buttons and keys

Button or key	Purpose
Edit	Activates the entry line for you to edit the object in the selected cell. (Only visible if the selected cell has content.)
Name	Converts the text you have entered on the entry line to a name. (Only visible when the entry line is active.)
CAS	Forces the calculation to be handled by the CAS. (Only visible when the entry line is active.)
$	Tap to enter the $ symbol. A shortcut when entering absolute references. (Only visible when the entry line is active.)
Format	Displays formatting options for the selected cell, block, column, row, or the entire spreadsheet. See See “Formatting options” on page 184.
Go To	Displays an input form for you to specify the cell you want to jump to.
Select	Sets the calculator to *select* mode so that you can easily select a block of cells using the cursor keys. It changes to Sel• to enable you to deselect cells. (You can also press, hold and drag to select a block of cells.)
Go → or Go ↓:	A toggle button that sets the direction the cursor moves after content has been entered in a cell.
Show	Displays the result in the selected cell in full-screen mode, with horizontal and vertical scrolling enabled. (Only visible if the selected cell has content.)
Sort	Enables you to select a column to sort by, and to sort it in ascending or descending order. (Only visible if cells are selected.)
Cancel	Cancel the input and clear the entry line.
OK	Accept and evaluate the input.

Button or key	Purpose (Continued)
Shift Esc Clear	Clears the spreadsheet.

Formatting options

The formatting options appear when you tap Format. They apply to whatever is currently selected: a cell, block, column, row, or the entire spreadsheet.



The options are:

- **Name**: displays an input form for you to give a name to whatever is selected
- **Number Format**: Auto, Standard, Fixed, Scientific, or Engineering. See “Home settings” on page 27 for more details.
- **Font Size**: Auto or from 10 to 22 point
- **Color**: color for the content (text, number, etc.) in the selected cells; the gray-dotted option represents Auto
- **Fill**: background color that fills the selected cells; the gray-dotted option represents Auto
- **Align** ↔: horizontal alignment—Auto, Left, Center, Right
- **Align** ↕: vertical alignment—Auto, Top, Center, Bottom
- **Column** ↔: displays an input form for you to specify the required width of the selected columns; only available if you have selected the entire spreadsheet or one or more entire columns.

  You can also change the width of a selected column with an open or closed horizontal pinch gesture.
- **Row** ↕: displays an input form for you to specify the required height of the selected rows; only available if you have selected the entire spreadsheet or one or more entire rows.

  You can also change the height of a selected row with an open or closed vertical pinch gesture.

- **show "**: show quote marks around strings in the body of the spreadsheet—Auto, Yes, No
- **Textbook**: display formulas in textbook format—Auto, Yes, No
- **Caching**: turn this option on to speed up calculations in spreadsheets with many formulas; only available if you have selected the entire spreadsheet

Format Parameters

Each format attribute is represented by a parameter that can be referenced in a formula. For example, `=D1(1)` returns the name of cell D1 (or nothing if D1 has not been named). The attributes that can be retrieved in a formulas by referencing its associated parameter are listed below.

Parameter	Attribute	Result
1	content	contents (or empty)
2	name	name (or empty)
3	number format	Standard = 0 Fixed = 1 Scientific = 2 Engineering = 3
4	number of decimal places	
5	font	System = 0 Small = 1 Medium = 2;
6	textbook mode (as opposed to algebraic mode)	Yes = 0; No = 1;
7	show strings in quotes	Yes = 0; No = 1
8	horizontal alignment	Left = 0; Center = 1; Right = 2
9	vertical alignment	Top = 0; Center = 1; Bottom = 2
10	background color	cell fill color

Parameter	Attribute	Result (Continued)
11	foreground color	contents color

As well as retrieving format attributes, you can set a format attribute (or cell content) by specifying it in a formula in the relevant cell. For example, wherever it is placed `g5(1):=6543` enters `6543` in cell g5. Any previous content in g5 is replaced. Similarly, `B3(5):=2` forces the contents of B3 to be displayed in medium font size.

Spreadsheet functions

As well as the functions on the **Math**, **CAS** and **Catlg** menus, you can use special spreadsheet functions. These can be found on the **App** menu, one of the Toolbox menus. Press [Toolbox], tap [App] and select `Spreadsheet`. The functions are described on "Spreadsheet functions" on page 314.

Remember to precede a function by an equals sign ([Shift] [.]) if you want the result to automatically update as the values it is dependent on change. Without an equals sign you will be entering just the current value.

9

Statistics 1Var app

The Statistics 1Var app can store up to ten data sets at one time. It can perform one-variable statistical analysis of one or more sets of data.

The Statistics 1Var app starts with the Numeric view which is used to enter data. The Symbolic view is used to specify which columns contain data and which column contains frequencies.

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

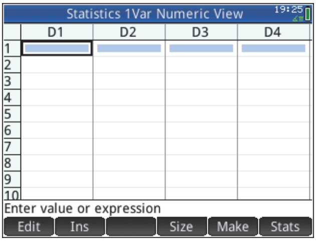
The values computed in the Statistics 1Var app are saved in variables, and can be re-used in Home view and in other apps.

Getting started with the Statistics 1Var app

Suppose that you are measuring the heights of students in a classroom to find the mean height. The first five students have the following measurements: 160 cm, 165 cm, 170 cm, 175 cm and180 cm.

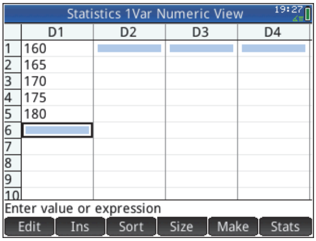
1. Open the Statistics 1Var app:

   Apps Info Select `Statistics 1Var`



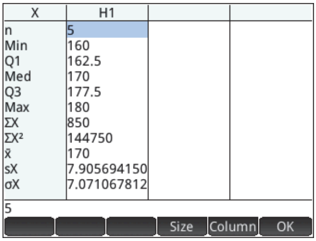
2. Enter the measurement data in column D1:

160 Enter
165 Enter
170 Enter
175 Enter
180 Enter



3. Find the mean of the sample.

   Tap Stats to see the statistics calculated from the sample data in `D1`. The mean ($\bar{x}$) is 170.

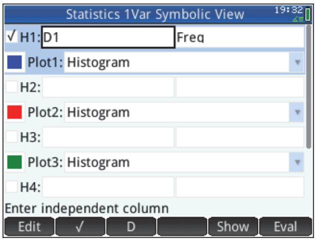


   There are more statistics than can be displayed on one screen. Thus you may need to scroll to see the statistic you are after.

   Note that the title of the column of statistics is `H1`. There are 5 data-set definitions available for one-variable statistics: `H1`–`H5`. If data is entered in `D1`, `H1` is automatically set to use `D1` for data, and the frequency of each data point is set to 1. You can select other columns of data from the Symbolic view of the app.

4. Tap OK to close the statistics window.

5. Press Symb to see the data-set definitions.



   The first field in each set of definitions is where you specify the column of data that is to be analyzed, the second field is where you specify the column that has the frequencies of each data point, and the third field (**Plotn**) is where you choose the type of plot that will represent the data in Plot view: Histogram, Box and Whisker, Normal Probability, Line, Bar, or Pareto.

Symbolic view: menu items

The menu items you can tap on in Symbolic view are:

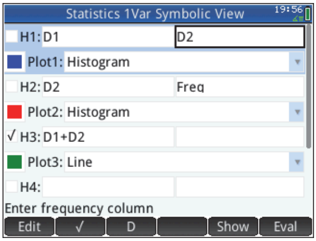
Menu item	**Purpose**
Edit	Copies the column variable (or variable expression) to the entry line for editing. Tap OK when done.
√	Selects (or deselects) a statistical analysis (H1–H5) for exploration.
D	Enters `D` directly (to save you having to press two keys).
Show	Displays the current expression in textbook format in full-screen view. Tap OK when done.
Eval	Evaluates the highlighted expression, resolving any references to other definitions.

To continue our example, suppose that the heights of the rest of the students in the class are measured and that each one is rounded to the nearest of the five values first recorded. Instead of entering all the new data in `D1`, we simply add another column, `D2`, that holds the frequencies of our five data points in `D1`.

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

6. Tap on **Freq** to the right of `H1` (or press ▶ to highlight the second `H1` field).

7. Enter the name of the column that you will contain the frequencies (in this example, `D2`):



D 2 OK

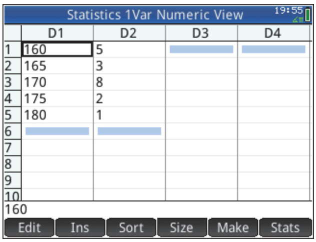
8. If you want to choose a color for the graph of the data in Plot view, see "Choose a color for plots" on page 74.

9. If you have more than one analysis defined in Symbolic view, deselect any analysis you are not currently interested in.

10. Return to Numeric view:

Num Setup

11. In column D2, enter the frequency data shown in the table above:

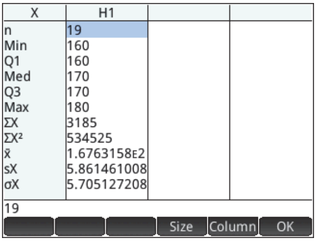


▶ 5 Enter
3 Enter
8 Enter
2 Enter
1 Enter

12. Recalculate the statistics:

    Stats

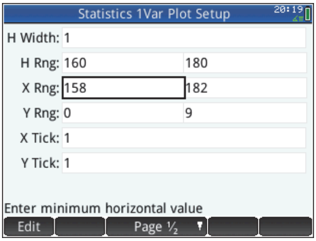
    The mean height now is approximately 167.631 cm.



13. Configure a histogram plot for the data.

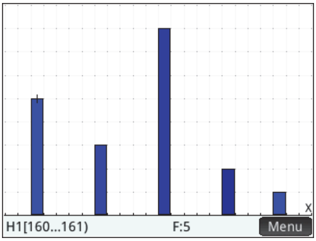
    OK Shift Plot (Setup)

    Enter parameters appropriate to your data. Those shown at the right will ensure that all the data in this particular example is displayed in Plot view.



14. Plot a histogram of the data.

    Plot



Entering and editing statistical data

Each column in Numeric view is a dataset and is represented by a variable named D0 to D9. There are three ways to get data into a column:

- Go to Numeric view and enter the data directly. See "Getting started with the Statistics 1Var app" on page 187 for an example.
- Go to Home view and copy the data from a list. For example, if you enter L1 Sto ▸ D1 in Home view, the items in list L1 are copied into column D1 in the Statistics 1Var app.

- Go to Home view and copy the data from a the Spreadsheet app. For example, suppose the data of interest is in A1:A10 in the Spreadsheet app and you want to copy it into column D7. With the Statistics 1Var app open, return to Home view and enter `Spreadsheet.A1:A10` Sto ▸ `D7` Enter.

Whichever method you use, the data you enter is automatically saved. You can leave this app and come back to it later. You will find that the data you last entered is still available.

After entering the data, you must define data sets—and the way they are to be plotted—in Symbolic view.

Numeric view: menu items

The menu items you can tap on in Numeric view are:

Item	Purpose
Edit	Copies the highlighted item into the entry line.
Ins	Inserts a zero value above the highlighted cell.
Sort	Sorts the data in various ways. See “Sort data values” on page 194.
Size	Displays a menu from which you can choose small font, medium font, or large font.
Make	Displays an input form for you to enter a formula that will generate a list of values for a specified column. See “Generating data” on page 193.

Item	Purpose (Continued)
Stats	Calculates statistics for each data set selected in Symbolic view. See “Computed statistics” on page 194.

Edit a data set

In Numeric view, highlight the data to change, type a new value, and press Enter. You can also highlight the data, tap Edit to copy it to the entry line, make your change, and press Enter.

Delete data

- To delete a data item, highlight it and press Del. The values below the deleted cell will scroll up one row.
- To delete a column of data, highlight an entry in that column and press Shift Esc (Clear). Select the column and tap OK.
- To delete all data in every column, press Shift Esc (Clear), select `All columns`, and tap OK.

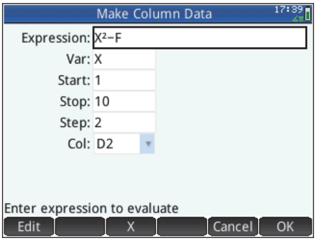
Insert data

1. Highlight the cell below where you want to insert a value.
2. Tap Ins and enter the value.

If you just want to add more data to the data set and it is not important where it goes, select the last cell in the data set and start entering the new data.

Generating data

You can enter a formula to generate a list of data points for a specified column. In the example at the right, 5 data-points will be placed in column D2. They will be generated by the expression $X^2 - F$ where X comes from the set {1, 3, 5, 7, 9}. These are the values between 1 and 10 that differ by 2. F is whatever value has been assigned to it elsewhere



(such as in Home view). If *F* happened to be 5, column D2 is populated with {–4, 4, 20, 44, 76}.

Sort data values

1. In Numeric view, place the highlight in the column you want to sort, and tap **Sort**.
2. Specify the sort order: `Ascending` or `Descending`.
3. If relevant, specify the Frequency column.
4. Tap **OK**.

Computed statistics

Tapping **Stats** displays the following results for each dataset selected in Symbolic view.

Statistic	Definition
`n`	Number of data points
`Min`	Minimum value
`Q1`	First quartile: median of values to left of median
`Med`	Median value
`Q3`	Third quartile: median of values to right of median
`Max`	Maximum value
ΣX	Sum of data values (with their frequencies)
ΣX^2	Sum of the squares of the data values
$\bar{x}$	Mean
sX	Sample standard deviation
σX	Population standard deviation
`serrX`	Standard error

When the data set contains an odd number of values, the median value is not used when calculating `Q1` and `Q3`. For example, for the data set {3,5,7,8,15,16,17}only the first three items—3, 5, and 7—are used to calculate Q1, and only the last three terms—5, 16, and 17—are used to calculate Q3.

Plotting

You can plot:

- Histograms
- Box-and-Whisker plots
- Normal Probability plots
- Line plots
- Bar graphs
- Pareto charts

Once you have entered your data and defined your data set, you can plot your data. You can plot up to five box-and-whisker plots at a time; however, with the other types, you can only plot one at a time.

To plot statistical data

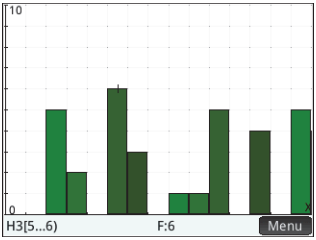
1. In the Symbolic view, select the data sets you want to plot.
2. From the **Plotn** menu, s elect the plot type.
3. For any plot, but especially for a histogram, adjust the plotting scale and range in the Plot Setup view. If you find histogram bars too fat or too thin, you can adjust them by changing the HWIDTH setting. (See “Setting up the plot (Plot Setup view)” on page 197.)
4. Press Plot. If the scaling is not to your liking, press View and select Autoscale.

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

Plot types

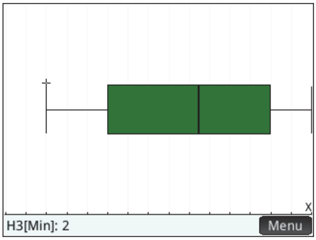
Histogram

The first set of numbers below the plot indicate where the cursor is. In the example at the right, the cursor is between 5 and 6 but not including 6), and the frequency for that range is 6. The data set is as defined by H3 in Symbolic view. You can see information about other ranges by pressing ▶ or ◀.



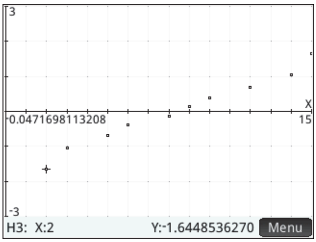
Box-and-Whisker plot

The left whisker marks the minimum data value. The box marks the first quartile, the median, and the third quartile. The right whisker marks the maximum data value. The numbers below the plot give the statistic at the cursor. You can see other statistics by pressing ▶ or ◀.



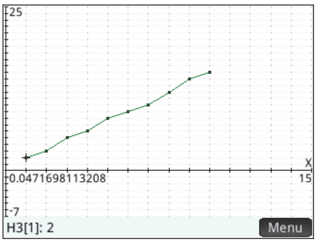
Normal probability plot

The normal probability plot is used to determine whether or not sample data is more or less normally distributed. The more linear the data appear, the more likely that the data is normally distributed.



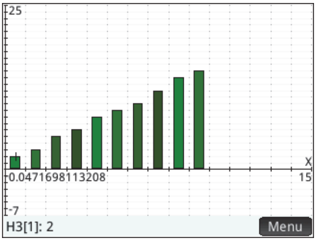
Line plot

The line plot connects points of the form (*x*, *y*), where *x* is the row number of the data point and *y* is its value.



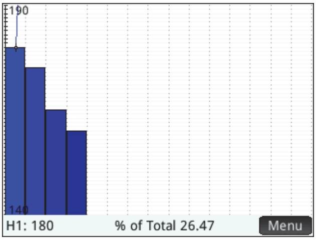
Bar graph

The bar graph shows the value of a data point as a vertical bar placed along the *x*-axis at the row number of the data point.



Pareto chart

A pareto chart places the data in descending order and displays each with its percentage of the whole.



Setting up the plot (Plot Setup view)

The Plot Setup view (Shift Plot Setup) enables you to specify many of the same plotting parameters as other apps (such as **X Rng** and **Y Rng**). There are two settings unique to the Statistics 1Var app:

Histogram width

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

Histogram range

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

Exploring the graph

The Plot view (Plot Setup) has zooming and tracing options, as well as coordinate display. The `Autoscale` option is available from the View menu (View Copy) as well as the Zoom menu.The View menu also enables you to view graphs in split-screen mode (as explained on page 81).

Plot view: buttons menu items

The menu items you can tap on in Plot view are:

Button	Purpose
Zoom	Displays the Zoom menu.
Trace•	Turns trace mode on or off. See “Zoom” on page 90.)
Defn	Displays the definition of the current statistical plot.
Menu	Shows or hides the menu.

10

Statistics 2Var app

The Statistics 2Var app can store up to ten data sets at one time. It can perform two-variable statistical analysis of one or more sets of data.

The Statistics 2Var app starts with the Numeric view which is used to enter data. The Symbolic view is used to specify which columns contain data and which column contains frequencies.

You can also compute statistics in Home and in the Spreadsheet app.

The values computed in the Statistics 2Var app are saved in variables. These can be referenced in Home view and in other apps.

Getting started with the Statistics 2Var app

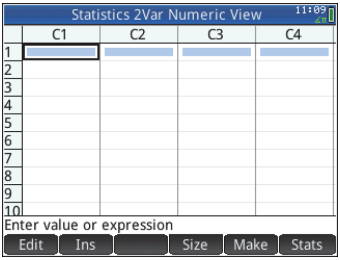
The following example uses the advertising and sales data in the table below. In the example, you will enter the data, compute summary statistics, fit a curve to the data, and predict the effect of more advertising on sales.

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

Open the Statistics 2Var app

1. Open the Statistics 2Var app:

   Apps Info Select `Statistics 2Var`.



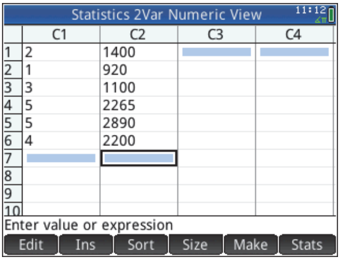
Enter data

2. Enter the advertising minutes data in column C1:

   2 Enter 1 Enter
   3 Enter 5 Enter
   5 Enter 4 Enter

3. Enter the resulting sales data in column C2:

   1400 Enter
   920 Enter
   1100 Enter
   2265 Enter
   2890 Enter
   2200 Enter



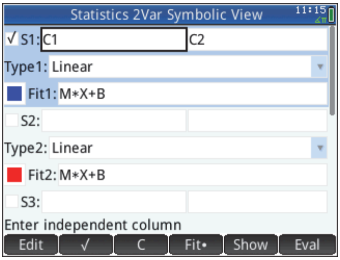
Choose data columns and fit

In Symbolic view, you can define up to five analyses of two-variable data, named `S1` to `S5`. In this example, we will define just one: `S1`. The process involves choosing data sets and a fit type.

4. Specify the columns that contain the data you want to analyze:

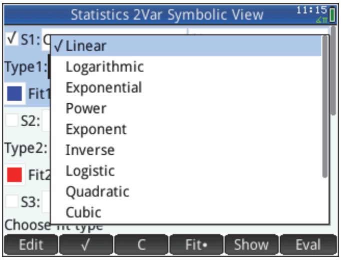
   Symb Setup

   In this case, C1 and C2 appear by default. But you could have entered your data into columns other than C1 and C2.



5. Select a fit:

   From the **Type 1** field select a fit. In this example, select `Linear`.



6. If you want to choose a color for the graph of the data in Plot view, see "Choose a color for plots" on page 74.

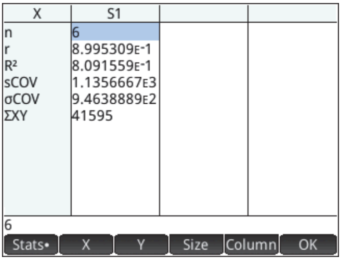
7. If you have more than one analysis defined in Symbolic view, deselect any analysis you are not currently interested in.

Explore statistics

8. Find the correlation, *r*, between advertising time and sales:

   Num Setup Stats

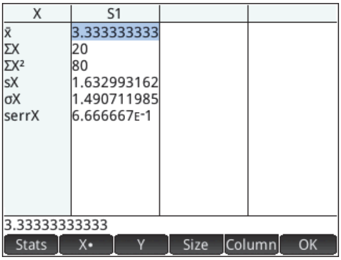
   The correlation is r=0.8995…



9. Find the mean advertising time ($\bar{x}$).

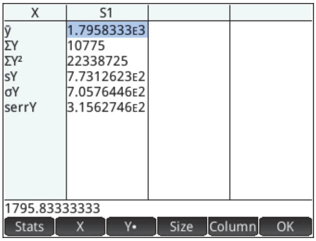
   X

   The mean advertising time, $\bar{x}$, is 3.33333… minutes.



10. Find the mean sales ($\bar{y}$).

Y



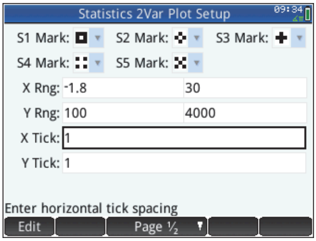
The mean sales, $\bar{y}$, is approximately $1,796.

Press OK to return to Numeric view.

Setup plot

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

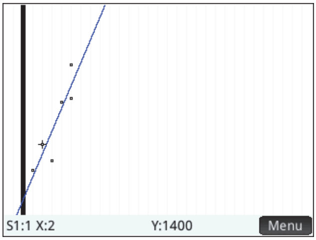
Shift Plot Setup (Setup)
▼ 100 Enter
4000 Enter



Plot the graph

12. Plot the graph.

Plot Setup

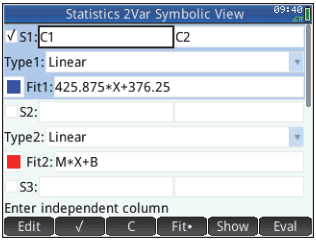


Notice that the regression curve (that is, a curve to best fit the data points) is plotted by default.

Display the equation

13. Return to the Symbolic view.

Symb Setup



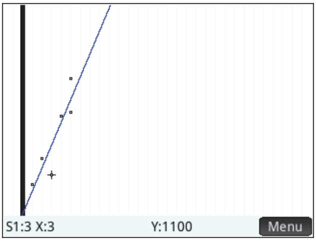
Note the expression in the **Fit1** field. It shows that the slope (*m*) of the regression line is 425.875 and the *y*-intercept (*b*) is 376.25.

Predict values

Let's now predict the sales figure if advertising were to go up to 6 minutes.

14. Return to the Plot view:

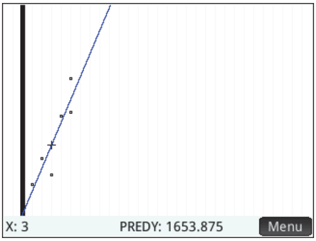
    Plot Setup

    The trace option is active by default. This option will move the cursor from data point to data point as you press ▶ or ◀. As you move from data point to data point, the corresponding *x*- and *y*-values appear at the bottom of the screen. In this example, the *x*-axis represents minutes of advertising and the *y*-axis represents sales.

    However, there is no data point for 6 minutes. Thus we cannot move the cursor to *x* = 6. Instead, we need to *predict* what *y* will be when *x* = 6, based on the data we do have. To do that, we need to trace the regression curve, not the data points we have.

15. Press ▼ or ▲ to set the cursor to trace the regression line rather than the data points.

    The cursor jumps from whatever data point it was on to the regression curve.

16. Repeatedly press ▶ until *x* = 6.

    If the *x*-value is not shown at the bottom left of the screen, tap Menu.

    When you reach x = 6, you will see that the **PREDY** value (also displayed at the bottom of the screen) reads 2931.5. Thus the model predicts that sales would rise to $2,931.50 if advertising were increased to 6 minutes.

Tip You could use the same tracing technique to predict—although roughly—how many minutes of advertising you would need to gain sales of a specified amount. However, a more accurate method is available: return to Home view and enter `Predx(s)` where *s* is the sales figure. `Predy` and `Predx` are app functions. They are discussed in detail in "Statistics 2Var app functions" on page 331.

Entering and editing statistical data

Each column in Numeric view is a dataset and is represented by a variable named `C0` to `C9`. There are three ways to get data into a column:

- Go to Numeric view and enter the data directly. See "Getting started with the Statistics 2Var app" on page 199 for an example.
- Go to Home view and copy the data from a list. For example, if you enter `L1` Sto ▸ `C1` in Home view, the items in list `L1` are copied into column `C1` in the Statistics 1Var app.
- Go to Home view and copy the data from a the Spreadsheet app. For example, suppose the data of interest is in A1:A10 in the Spreadsheet app and you want to copy it into column `C7`. With the Statistics 2Var app open, return to Home view and enter `Spreadsheet.A1:A10` Sto ▸ `C7` Enter ≈.

TNote A data column must have at least four data points to provide valid two-variable statistics.

Whichever method you use, the data you enter is automatically saved. You can leave this app and come back to it later. You will find that the data you last entered is still available.

After entering the data, you must define data sets—and the way they are to be plotted—in Symbolic view.

Numeric view menu items

The buttons you can tap on in Numeric view are:

Button	Purpose
Edit	Copies the highlighted item to the entry line.
Ins	Inserts a new cell above the highlighted cell (and gives it a value of 0).
Sort	Opens an input form for you to choose to sort the data in various ways.
Size	Displays a menu for you to choose the small font, medium font, or large font.
Make	Opens an input form for you to create a sequence based on an expression, and to store the result in a specified data column. See "Generating data" on page 193.
Stats	Calculates statistics for each data set selected in Symbolic view. See "Computed statistics" on page 208.

Edit a data set

In Numeric view, highlight the data to change, type a new value, and press Enter. You can also highlight the data, tap Edit, make your change, and tap OK.

Delete data

- To delete a data item, highlight it and press Del. The values below the deleted cell will scroll up one row.
- To delete a column of data, highlight an entry in that column and press Shift Esc (Clear). Select the column and tap OK.
- To delete all data in every column, press Shift Esc (Clear), select `All columns`, and tap OK.

Insert data

Highlight the cell below where you want to insert a value. Tap Ins and enter the value.

If you just want to add more data to the data set and it is not important where it goes, select the last cell in the data set and start entering the new data.

Sort data values

1. In Numeric view, place the highlight in the column you want to sort, and tap Sort.
2. Specify the Sort Order: `Ascending` or `Descending`.
3. Specify the `Independent` and `Dependent` data columns. Sorting is by the *independent* column. For instance, if Age is `C1` and Income is `C2` and you want to sort by Income, then you make `C2` the independent column 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 in the `Frequency` field.
4. Tap OK.

Defining a regression model

You define a regression model in Symbolic view. There are three ways to do so:

- Accept the default option to fit the data to a straight line.
- Choose a pre-defined fit type (logarithmic, exponential, and so on).
- Enter your own mathematical expression. The expression will be plotted so that you can see how closely it fits the data points.

Choose a fit

1. Press Symb to display the Symbolic view.
2. For the analysis you are interested in (S1 through S5), select the **Type** field.
3. Tap the field again to see the menu of fit types.
4. Select your preferred fit type from the menu. (See "Fit models" on page 207.)

Fit models

Twelve fit models are available:

Fit model	Meaning
Linear	(Default.) Fits the data to a straight line: $y = mx+b$. Uses a least-squares fit.
Logarithmic	Fits the data to a logarithmic curve: $y = m \ln x + b$.
Power	Fits the data to a power curve: $y = bx^m$.
Exponent	Fits the data to an exponent curve: $y = ab^x$.
Inverse	Fits the data to an inverse variation: $y = \frac{m}{x+b}$
Logistic	Fits the data to a logistic curve: $y = \frac{L}{1+ae^{(-bx)}}$ where *L* is the saturation value for growth. You can store a positive real value in *L*, or—if *L*=0—let *L* be computed automatically.
Quadratic	Fits the data to a quadratic curve: $y = ax^2+bx+c$. Needs at least three points.
Cubic	Fits the data to a cubic polynomial: $y = ax^3 + b^2x + cx + d$
Quartic	Fits to a quartic polynomial, $y = ax^4 + bx^3 + cx^2 + dx + e$
Trigonometric	Fits the data to a trigonometric curve: $y = a \cdot \sin(bx+c) + d$. Needs at least three points.
User Defined	Define your own fit (see below).

To define your own fit

1. Press Symb Setup to display the Symbolic view.
2. For the analysis you are interested in (S1 through S5), select the **Type** field.
3. Tap the field again to see a menu of fit types.
4. Select `User Defined` from the menu.
5. Select the corresponding **Fit**$_n$ field.
6. Enter an expression and press Enter. The independent variable must be X, and the expression must not contain any unknown variables. Example: $1.5 \times \cos x + 0.3 \times \sin x$. Note that in this app, variables must be entered in uppercase.

Computed statistics

When you tap Stats, three sets of statistics become available. By default, the statistics involving both the independent and dependent columns are shown. Tap X to see the statistics involving just the independent column or Y to display the statistics derived from the dependent column. Tap Stats to return to the default view. The tables below describe the statistics displayed in each view.

The statistics computed when you tap Stats are:

Statistic	Definition
`n`	The number of data points.
`r`	Correlation coefficient of the independent and dependent data columns, based only on the linear fit (regardless of the fit type chosen). Returns a value between –1 and 1, where 1 and –1 indicate best fits.
R^2	The coefficient of determination, that is, the square of the correlation coefficient. The value of this statistics is dependent on the Fit type chosen. A measure of 1 indicates a perfect fit.

Statistic	Definition (Continued)
sCOV	Sample covariance of independent and dependent data columns.
σ COV	Population covariance of independent and dependent data columns.
ΣXY	Sum of all the individual products of of x and y.

The statistics displayed when you tap X are:

Statistic	Definition
$\bar{x}$	Mean of x- (independent) values.
ΣX	Sum of x-values.
ΣX^2	Sum of x^2-values.
sX	The sample standard deviation of the independent column.
σX	The population standard deviation of the independent column.
serrX	the standard error of the independent column

The statistics displayed when you tap Y are:

Statistic	Definition
$\bar{y}$	Mean of y- (dependent) values.
ΣY	Sum of y-values.
ΣY^2	Sum of y^2-values.
sY	The sample standard deviation of the dependent column.
σY	The population standard deviation of the dependent column.
serrY	The standard error of the dependent column.

Plotting statistical data

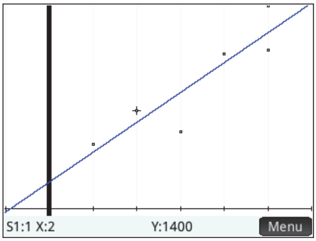
Once you have entered your data, selected the data set to analyze and specified your fit model, you can plot your data. You can plot up to five scatter plots at a time.

1. In Symbolic view, select the data sets you want to plot.
2. Make sure that the full range of your data will be plotted. You do this by reviewing (and adjusting, if necessary), the **X Rng** and **Y Rng** fields in Plot Setup view. (Shift Plot Setup).
3. Press Plot Setup.

   If the data set and regression line are not ideally positioned, Press View Copy and select `Autoscale`. Autoscale can be relied upon to give a good starting scale which can then be adjusted later in the Plot Setup view.

Tracing a scatter plot

The figures below the plot indicate that the cursor is at the second data point of `S1`, at ((2, 1400). Press ▶ to move to the next data point and display information about it.



Note: if you find that the tracer cursor is moving along the regression line rather than from data point to data point, press ▲ or ▼ to select the points and not the line.

Tracing a curve

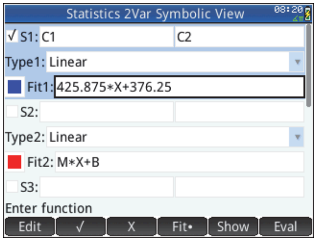
If the regression line is not showing, tap Fit. The coordinates of the tracer cursor are shown at the bottom of the screen. (If they are not visible, tap Menu.)

Note: if you find that the tracer cursor is moving between the data points rather than along the regression line, press ▲ or ▼ to select the line and not the points.

Tap Defn to display the data sets that being represented by of the regression line.

Press Symb to see the equation of the regression line in Symbolic view.

If the equation is too wide for the screen, select it and press Show.



The example above shows that the slope of the regression line (m) is 425.875 and the *y*-intercept (b) is 376.25.

Plot view: menu items

The menu items in Plot view are:

Button	Purpose
Zoom	Displays the Zoom menu.
Trace•	Turns trace mode on or off.
Fit•	Shows or hides a curve that best fits the data points according to the selected regression model.
Go To	Enables you to specify a value on the regression line to jump to (or a data point to jump to if your cursor is on a data point rather than on the regression line). You might need to press ▲ or ▼ to move the cursor to the object of interest: the regression line or the data points.
Menu	Shows or hides the menu buttons.

Plot setup

As with all the apps that provide a plotting feature, he Plot Setup view—Shift Plot (Setup)—enables you to set the range and appearance of Plot view. The common settings available are discussed in “Common operations in Plot Setup view” on page 86. The Plot Setup view in the Statistics 2Var app has two additional settings:

Plotting mark

Page 1 of the Plot Setup view has fields named S1MARK through S5MARK. These fields enable you to specify one of five symbols to use to represent the data points in each data set. This will help you distinguish data sets in Plot view if you have chosen to plot more than one.

Connect

Page 2 of the Plot Setup view has a **Connect** field. If you choose this option, straight lines join the data points in Plot view.

Predicting values

PredX is a function that predicts a value for X given a value for Y. Likewise, PredY is a function that predicts a value for Y given a value for X. In both cases, the prediction is based on the equation that best fits the data according to the specified fit type.

You can predict values in the Plot view of the Statistics 2Var app and also in Home view.

In Plot view

1. In the Plot view, tap Fit to display the regression curve for the data set (if it is not already displayed).
2. Make sure the trace cursor is on the regression curve. (Press ▲ or ▼ if it is not.)
3. Press ▶ or ◀. The cursor moves along the regression curve and the corresponding X and Y values are displayed across the bottom of the screen. (If these values are not visible, tap Menu.)

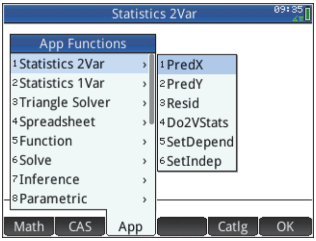
You can force the cursor to a specific X value by tapping Go To, entering the value and tapping OK. The cursor jumps to the specified point on the curve.

In Home view

If the Statistics 2Var app is the active app, you can also predict X and Y values in the Home view.

- Enter PredX(*Y*) Enter to predict the X value for the specified Y value.
- Enter PredY(*X*) Enter to predict the Y value for the specified X value.

You can type `PredX` and `PredY` directly on the entry line, or select them from the App functions menu (under the `Statistics 2Var` category). The App functions menu is one of the Toolbox menus ( ).



HINT In cases where more than one fit curve is displayed, the `PredX` and `PredY` functions use the first active fit defined in the Symbolic view.

Troubleshooting a plot

If you have problems plotting, check the following:

- The fit (that is, regression model) that you intended to select is the one selected.
- Only those data sets you want to analyze or plot are selected in Symbolic view.
- The plotting range is suitable. Try pressing View Copy and selecting `Autoscale`, *or* adjust the plotting parameters in Plot Setup view.
- Ensure that both paired columns contain data, and are of the same length.
- Ensure that a paired column of frequency values is the same length as the data column to which it is associated.

11

Inference app

The Inference app enables you to calculate confidence intervals and undertake hypothesis tests based on the Normal Z-distribution or Student's t-distribution.

Based on statistics from one or two samples, you can test hypotheses and find confidence intervals for the following quantities:

- mean
- proportion
- difference between two means
- difference between two proportions

Example data

The Inference app comes with sample data (which you can always restore by resetting the app). This sample data is useful in helping you gain an understanding app. The calculator's on-line help provides a description of what the sample data represents.

Getting started with the Inference app

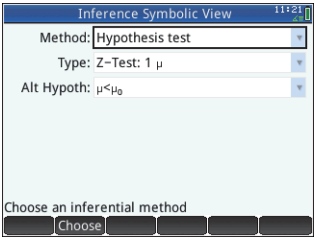
Let's conduct a Z-Test on one mean using the sample data.

Open the Inference app

1. Open the Inference app:

   Apps Info Select `Inference`

   The Inference app opens in Symbolic view.



Symbolic view options

The table below summarizes the options available in Symbolic view for the two inference methods: hypothesis test and confidence interval.

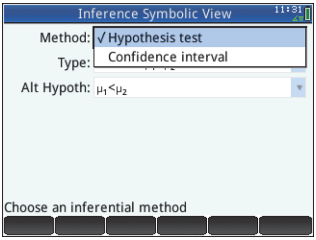
Hypothesis Test	**Confidence Interval**
Z-Test: 1 μ, the Z-Test on one mean	Z-Int: 1 μ, the confidence interval for one mean, based on the Normal distribution
Z-Test: $\mu_1 - \mu_2$, the Z-Test on the difference between two means	Z-Int: $\mu_1 - \mu_2$, the confidence interval for the difference between two means, based on the Normal distribution
Z-Test: 1 π, the Z-Test on one proportion	Z-Int: 1 π, the confidence interval for one proportion, based on the Normal distribution
Z-Test: $\pi_1 - \pi_2$, the Z-Test on the difference between two proportions	Z-Int: $\pi_1 - \pi_2$, the confidence interval for the difference between two proportions, based on the Normal distribution
T-Test: 1 μ, the T-Test on one mean	T-Int: 1 μ, the confidence interval for one mean, based on the Student's t-distribution
T-Test: $\mu_1 - \mu_2$, the T-Test on the difference between two means	T-Int: $\mu_1 - \mu_2$, the confidence interval for the difference between two means, based on the Student's t-distribution

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

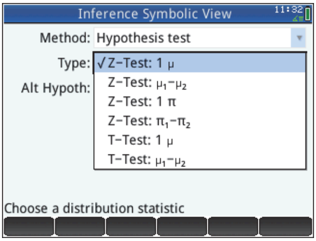
In this section, we will conduct a Z-Test on one mean on the example data to illustrate how the app works.

Select the inference method

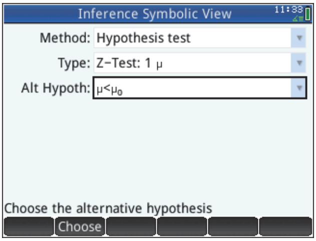
2. `Hypothesis Test` is the default inference method. If it is not selected, tap on the Method field and select it.



3. Choose the type of test. In this case, select `Z-Test: 1` μ from the **Type** menu.

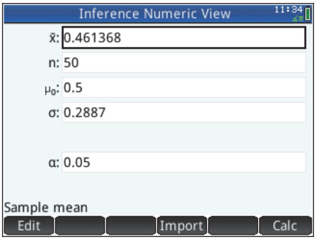


4. Select an alternative hypothesis. In this case, select $\mu < \mu_0$ from the **Alt Hypoth** menu.



Enter data

5. Go to Numeric view to see the sample data.



The table below describes the fields in this view for the sample data.

Field name	Definition
$\bar{x}$	Sample mean

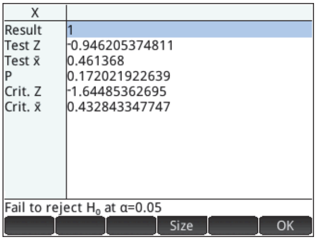
Field name	Definition (Continued)
n	Sample size
μ_0	Assumed population mean
σ	Population standard deviation
α	Alpha level for the test

We'll leave the data as it is for now, but the Numeric view is where you add the data you are particularly interested in.

Display the test results

6. Display the test results:

   Calc



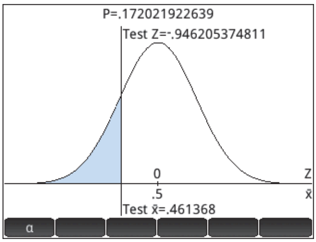
   The test distribution value and its associated probability are displayed, along with the critical value(s) of the test and the associated critical value(s) of the statistic.

   Tap OK to return to Numeric view.

Plot the test results

7. Display a graphical view of the test results:

   Plot Setup



   The graph of the distribution is displayed, with the test Z-value marked. The corresponding X-value is also shown.

   Tap α to see the critical Z-value. With the alpha level showing, you can press or to decrease or increase the α-level.

Importing statistics

The Inference app can calculate confidence intervals and test hypotheses based on data in the Statistics 1Var and Statistics 2Var apps. The following example illustrates the process.

A series of six experiments gives the following values as the boiling point of a liquid:

82.5, 83.1, 82.6, 83.7, 82.4, and 83.0

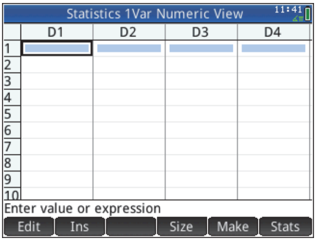
Based on this sample, we want to estimate the true boiling point at the 90% confidence level.

Open the Statistics 1Var app

1. Open the Statistics 1Var app:

   Apps Info Select

   `Statistics 1Var`



Clear unwanted data

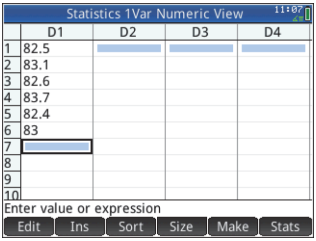
2. If there is unwanted data in the app, clear it:

   Shift Esc Clear All columns

Enter data

3. In column D1, enter the boiling points found during the experiments.

   82 . 5 Enter
   83 . 1 Enter
   82 . 6 Enter
   83 . 7 Enter
   82 . 4 Enter
   83 Enter

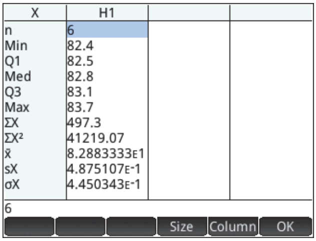


Calculate statistics

4. Calculate statistics:

Stats

The statistics calculated will now be imported into the Inference app.



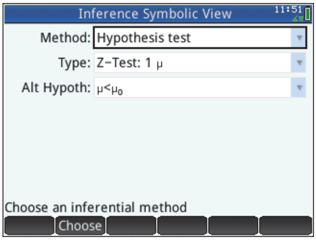
5. Tap OK to close the statistics window.

Open the Inference app

6. Open the Inference app and clear the current settings.

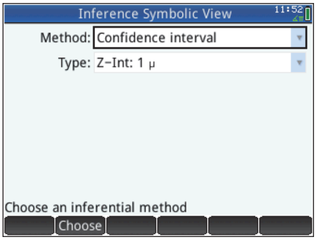
   Apps Info Select `Inference`

   Shift Esc Clear

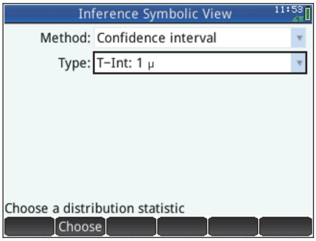


Select inference method and type

7. Tap on the **Method** field and select `Confidence Interval`.



8. Tap on **Type** and select `T-Int: 1 μ`



Import the data

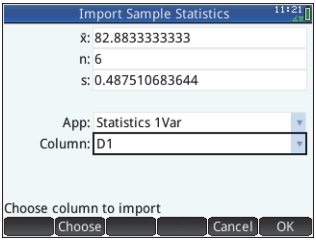
9. Open Numeric view:

   Num Setup

10. Specify the data you want to import:

    Tap Import.

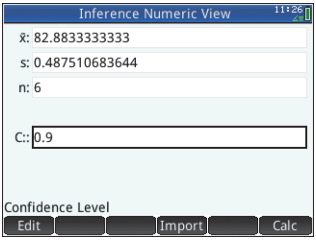
11. From the **App** field select the statistics app that has the data you want to import.



12. In the **Column** field specify the column in that app where the data is stored. (D1 is the default.)

13. Tap OK.

14. Specify a 90% confidence interval in the **C** field.



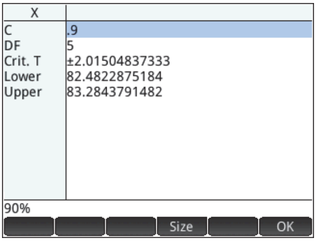
Display results numerically

15. Display the confidence interval in Numeric view:

Calc

16. Return to Numeric view:

OK

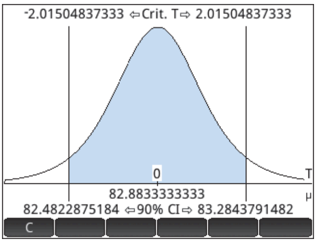


Display results graphically

17. Display the confidence interval in Plot view.

Plot Setup

You can see that we can be 90% confident that the true boiling point lies between 82.4822… and 83.2843…



Hypothesis tests

You use hypothesis tests to test the validity of hypotheses about the statistical parameters of one or two populations.

The tests are based on statistics of samples of the populations.

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

One-Sample Z-Test

Menu name

Z-Test: 1 μ

On the basis of statistics from a single sample, this test measures the strength of the evidence for a selected hypothesis against the null hypothesis. The null hypothesis is that the population mean equals a specified value, H_0: $\mu = \mu_0$.

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

$$H_1: \mu < \mu_0$$
$$H_1: \mu > \mu_0$$
$$H_1: \mu \neq \mu_0$$

Inputs

The inputs are:

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

Results The results are:

Result	Description
Test Z	Z-test statistic
Test $\bar{x}$	Value of $\bar{x}$ associated with the test Z-value
P	Probability associated with the Z-Test statistic
Critical Z	Boundary value(s) of Z associated with the α level that you supplied
Critical $\bar{x}$	Boundary value(s) of $\bar{x}$ required by the α value that you supplied

Two-Sample Z-Test

Menu name Z-Test: $\mu_1 - \mu_2$

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

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

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

Inputs The inputs are:

Field name	Definition
$\bar{x}_1$	Sample 1 mean
$\bar{x}_2$	Sample 2 mean
n_1	Sample 1 size
n_2	Sample 2 size

Field name	Definition (Continued)
σ_1	Population 1 standard deviation
σ_2	Population 2 standard deviation
α	Significance level

Results

The results are:

Result	Description
Test Z	Z-Test statistic
Test $\Delta\ \bar{x}$	Difference in the means associated with the test Z-value
P	Probability associated with the Z-Test statistic
Critical Z	Boundary value(s) of Z associated with the α level that you supplied
Critical $\Delta\ \bar{x}$	Difference in the means associated with the α level you supplied

One-Proportion Z-Test

Menu name

Z-Test: $1\ \pi$

On the basis of statistics from a single sample, this test measures the strength of the evidence for a selected hypothesis against the null hypothesis. The null hypothesis is that the proportion of successes is an assumed value, $H_0: \pi = \pi_0$.

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

$$H_1: \pi < \pi_0$$
$$H_1: \pi > \pi_0$$
$$H_1: \pi \neq \pi_0$$

Inputs

The inputs are:

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

Results

The results are:

Result	Description
Test Z	Z-Test statistic
Test $\hat{p}$	Proportion of successes in the sample
P	Probability associated with the Z-Test statistic
Critical Z	Boundary value(s) of Z associated with the α level that you supplied
Critical $\hat{p}$	Proportion of successes associated with the level you supplied

Two-Proportion Z-Test

Menu name

Z-Test: $\pi_1 - \pi_2$

On the basis of statistics from two samples, each from a different population, this test measures the strength of the evidence for a selected hypothesis against the null hypothesis. The null hypothesis is that the proportions of successes in the two populations are equal, H_0: $\pi_1 = \pi_2$.

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

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

Inputs

The inputs are:

Field name	Definition
x_1	Sample 1 success count
x_2	Sample 2 success count
n_1	Sample 1 size
n_2	Sample 2 size
α	Significance level

Results

The results are:

Result	Description
Test Z	Z-Test statistic
Test $\Delta\ \hat{p}$	Difference between the proportions of successes in the two samples that is associated with the test Z-value
P	Probability associated with the Z-Test statistic
Critical Z	Boundary value(s) of Z associated with the α level that you supplied
Critical $\Delta\ \hat{p}$	Difference in the proportion of successes in the two samples associated with the level you supplied

One-Sample T-Test

Menu name

T-Test: 1 μ

This test is used when the population standard deviation is not known. On the basis of statistics from a single sample, this test measures the strength of the evidence for a selected hypothesis against the null hypothesis. The null hypothesis is that the sample mean has some assumed value, $H_0: \mu = \mu_0$.

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

$$H_1: \mu < \mu_0$$
$$H_1: \mu > \mu_0$$
$$H_1: \mu \neq \mu_0$$

Inputs

The inputs are:

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

Results

The results are:

Result	Description
Test T	T-Test statistic
Test $\bar{x}$	Value of $\bar{x}$ associated with the test t-value
P	Probability associated with the T-Test statistic
DF	Degrees of freedom

Result	Description (Continued)
Critical T	Boundary value(s) of T associated with the α level that you supplied
Critical $\bar{x}$	Boundary value(s) of $\bar{x}$ required by the α value that you supplied

Two-Sample T-Test

Menu name

T-Test: $\mu_1 - \mu_2$

This test is used when the population standard deviation is not known. On the basis of statistics from two samples, each sample from a different population, this test measures the strength of the evidence for a selected hypothesis against the null hypothesis. The null hypothesis is that the two populations means are equal, H_0: $\mu_1 = \mu_2$.

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

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

Inputs

The inputs are:

Field name	Definition
$\bar{x}_1$	Sample 1 mean
$\bar{x}_2$	Sample 2 mean
s_1	Sample 1 standard deviation
s_2	Sample 2 standard deviation
n_1	Sample 1 size
n_2	Sample 2 size
α	Significance level

Field name	Definition
`Pooled`	Check this option to pool samples based on their standard deviations

Results

The results are:

Result	Description
Test T	T-Test statistic
Test $\Delta\bar{x}$	Difference in the means associated with the test t-value
P	Probability associated with the T-Test statistic
DF	Degrees of freedom
Critical T	Boundary values of T associated with the α level that you supplied
Critical $\Delta\bar{x}$	Difference in the means associated with the α level you supplied

Confidence intervals

The confidence interval calculations that the HP Prime can perform are based on the Normal Z-distribution or Student's t-distribution.

One-Sample Z-Interval

Menu name

Z-Int: $1\,\mu$

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

Inputs

The inputs are:

Field name	Definition
$\bar{x}$	Sample mean

Field name	Definition
n	Sample size
σ	Population standard deviation
C	Confidence level

Results

The results are:

Result	Description
C	Confidence level
Critical Z	Critical values for Z
Lower	Lower bound for μ
Upper	Upper bound for μ

Two-Sample Z-Interval

Menu name

Z-Int: $\mu_1 - \mu_2$

This option uses the Normal Z-distribution to calculate a confidence interval for the difference between the means of two populations, $\mu_1 - \mu_2$, when the population standard deviations, σ_1 and σ_2, are known.

Inputs

The inputs are:

Field name	Definition
$\bar{x}_1$	Sample 1 mean
$\bar{x}_2$	Sample 2 mean
n_1	Sample 1 size
n_2	Sample 2 size
σ_1	Population 1 standard deviation
σ_2	Population 2 standard deviation

Field name	Definition
C	Confidence level

Results The results are:

Result	Description
C Critical Z	Confidence level Critical values for Z
Lower Upper	Lower bound for $\Delta \mu$ Upper bound for $\Delta \mu$

One-Proportion Z-Interval

Menu name Z-Int: 1π

This option uses the Normal Z-distribution to calculate a confidence interval for the proportion of successes in a population for the case in which a sample of size n has a number of successes x.

Inputs The inputs are:

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

Results The results are:

Result	Description
C Critical Z Lower	Confidence level Critical values for Z Lower bound for π

Result	Description
Upper	Upper bound for π

Two-Proportion Z-Interval

Menu name Z-Int: $\pi_1 - \pi_2$

This option uses the Normal Z-distribution to calculate a confidence interval for the difference between the proportions of successes in two populations.

Inputs The inputs are:

Field name	Definition
$\bar{x}_1$	Sample 1 success count
$\bar{x}_2$	Sample 2 success count
n_1	Sample 1 size
n_2	Sample 2 size
C	Confidence level

Results The results are:

Result	Description
C	Confidence level
Critical Z	Critical values for Z
Lower	Lower bound for $\Delta\pi$
Upper	Upper bound for $\Delta\pi$

One-Sample T-Interval

Menu name T-Int: 1 μ

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

Inputs

The inputs are:

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

Results

The results are:

Result	Description
C	Confidence level
DF	Degrees of freedom
Critical T	Critical values for T
Lower	Lower bound for μ
Upper	Upper bound for μ

Two-Sample T-Interval

Menu name

T-Int: $\mu_1 - \mu_2$

This option uses the Student's t-distribution to calculate a confidence interval for the difference between the means of two populations, $\mu_1 - \mu_2$, when the population standard deviations, $\sigma_1$and σ_2, are unknown.

Inputs

The inputs are:

Result	Definition
$\bar{x}_1$	Sample 1 mean
$\bar{x}_2$	Sample 2 mean

Result	Definition
s_1	Sample 1 standard deviation
s_2	Sample 2 standard deviation
n_1	Sample 1 size
n_2	Sample 2 size
C	Confidence level
Pooled	Whether or not to pool the samples based on their standard deviations

Results

The results are:

Result	Description
C	Confidence level
DF	Degrees of freedom
Critical T	Critical values for T
Lower	Lower bound for $\Delta\mu$
Upper	Upper bound for $\Delta\mu$

12

Solve app

The Solve app enables you to define up to ten equations or expressions each with as many variables as you like. You can solve a single equation or expression for one of its variables, based on a seed value. You can also solve a system of equations (linear or non-linear), again using seed values.

Note the differences between an equation and an expression:

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

For brevity, the term *equation* in this chapter will cover both equations and expressions.

Solve works only with real numbers.

Getting started with the Solve app

The Solve app uses the customary app views: Symbolic, Plot and Numeric described in chapter 4.

For a description of the menu buttons available in this app, see:

- “Symbolic view: Summary of menu buttons” on page 76
- “Plot view: Summary of menu buttons” on page 86, and
- “Numeric view: Summary of menu buttons” on page 94

One equation

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

The equation to solve is:

$$V^2 = U^2 + 2AD.$$

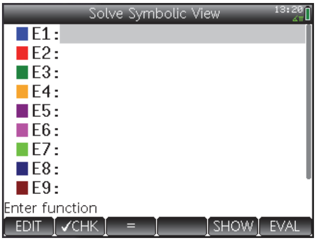
where V = final speed, U = initial speed, A = acceleration needed, and D = distance.

Open the Solve app

1. Open the Solve app.

   Apps Info Select `Solve`

   The Solve app starts in Symbolic view, where you specify the equation to solve.



NOTE

In addition to the built-in variables, you can use one or more variables you created yourself (either in Home view or in the CAS). For example, if you've created a variable called ME, you could include it in an equation such as this: $Y^2 = G^2 + ME$.

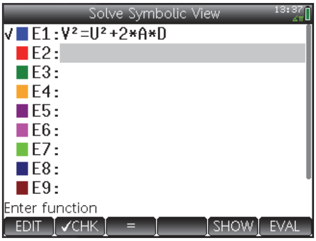
Functions defined in other apps can also be referenced in the Solve app. For example, if you have defined F1(X) to be $X^2 + 10$ in the Function app, you can enter `F1(X)=50` in the Solve app to solve the equation $X^2 + 10 = 50$.

Clear the app and define the equation

2. If you have no need for any equations or expressions already defined, press Shift Esc Clear (Clear). Tap OK to confirm your intention to clear the app.

3. Define the equation.

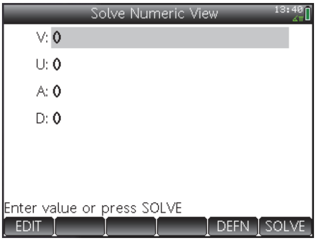
   ALPHA alpha V x^2 Shift = ALPHA alpha U x^2 + 2 ALPHA alpha A ALPHA alpha D Enter



Enter known variables

4. Display the Numeric view.

Num Setup



Here you specify the values of the known variables, highlight the variable that you want to solve for, and tap Solve.

5. Enter the values for the known variables.

   2 7 . 7 8 Enter 1 6 . 6 7 Enter ▼ 1 0 0 Enter

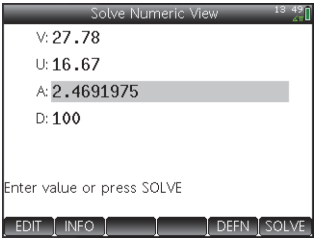
NOTE Some variables may already have values against them when you display the Numeric view. This occurs if the variables have been assigned values elsewhere. For example, in Home view you might have assigned 10 to variable U: 10 Sto ▸ U. Then when you open the Numeric view to solve an equation with U as a variable, 10 will be the default value for U. This also occurs if a variable has been given a value in some previous calculation (in an app or program).

To reset all pre-populated variables to zero, press Shift Esc Clear.

Solve the unknown variable

6. Solve for the unknown variable (A).

   Move the cursor to the A field and tap Solve.



   Therefore, the acceleration needed to increase the speed of a car from 16.67 m/s (60 kph) to 27.78 m/s (100 kph) over a distance of 100 m is approximately 2.4692 m/s^2.

   The equation for A is $(V^2 - U^2)/2D$. This is a linear equation. Hence we can conclude that there are no further solutions for A. We can also see this if we plot the equation.

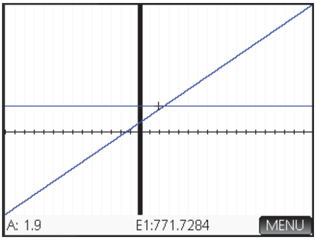
Plot the equation

The Plot view shows one graph for each side of the solved equation. You can choose any of the variables to be the independent variable by selecting it in Numeric view. So in this example make sure that A is highlighted.

The current equation is $V^2 = U^2 + 2AD$. The plot view will plot two equations, one for each side of the equation. One of these is $Y = V^2$, with $V = 27.78$, making $Y = 771.7284$. This graph will be a horizontal line. The other graph will be $Y = U^2 + 2AD$ with $U = 16.67$and $D = 100$, making, $Y = 200A + 277.8889$. This graph is also a line. The desired solution is the value of A where these two lines intersect.

7. Plot the equation for variable `A`.

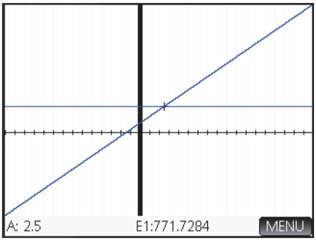
   View Copy

   Select `Auto Scale`.

   Select `Both sides of En` (where `n` is the number of the selected equation)

8. Tap Menu and then Trace•. Using the cursor keys, move the trace cursor along either graph until it nears the intersection. Note that the value of `A` displayed near the bottom left corner of the screen closely matches the value of A you calculated above.

   The Plot view provides a convenient way to find an approximation to a solution when you suspect that there are a number of solutions. Move the trace cursor close to the solution (that is, the intersection) of interest to you and then open Numeric view. The solution given in Numeric view will be will be for the solution nearest the trace cursor.

NOTE By dragging a finger horizontally or vertically across the screen, you can quickly see parts of the plot that are initially outside the x and y ranges you set.

Several equations

You can define up to ten equations and expressions in Symbolic view and select those you want to solve together as a system. For example, suppose you want to solve the system of equations consisting of:

- $X^2 + Y^2 = 16$ and
- $X - Y = -1$

Open the Solve app

1. Open the Solve app.

   Apps Select `Solve`

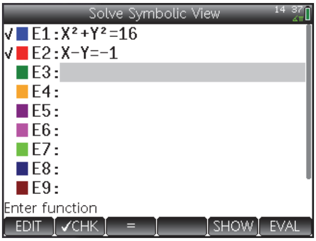
2. If you have no need for any equations or expressions already defined, press Shift Esc (Clear). Tap OK to confirm your intention to clear the app.

Define the equations

3. Define the equations.

   ALPHA X x^2 + ALPHA Y x^2 Shift = 16 Enter

   ALPHA X − ALPHA Y Shift = +/− 1 Enter

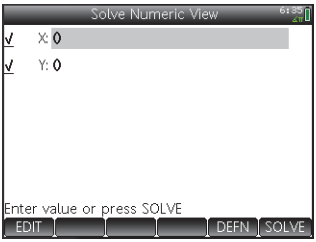


   Make sure that both equations are selected, as we are looking for values of *X* and *Y* that satisfy both equations.

Enter a seed value

4. Display Numeric view.

   Num



   Unlike the example above, in this example we have no values for any variable. You can either enter a seed value for one of the variables, or let the calculator provide a solution. (Typically a seed value is a value that directs the calculator to provide, if possible, a solution that is closest to it rather than some other value.) In this example, let's look for a solution in the vicinity of $X = 2$.

5. Enter the seed value in the X field:

   2 OK

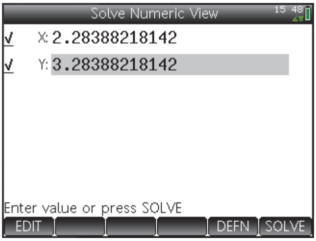
   The calculator will provide one solution (if there is one) and you will not be alerted if there are multiple solutions. Vary the seed values to find other potential solutions.

6. Select the variables you want solutions for. In this example we want to find values for both X and Y, so make sure that both variables are selected.

   Note too that if you have more than two variables, you can enter seed values for more than one of them.

Solve the unknown variables

7. Tap Solve to find a solution near $X = 2$ that satisfies each selected equation. Solutions, if found, are displayed beside each selected variable.



Limitations

You cannot plot equations if more than one is selected in Symbolic view.

The HP Prime will not alert you to the existence of multiple solutions. If you suspect that another solution exists close to a particular value, repeat the exercise using that value as a seed. (In the example just discussed, you will find another solution if you enter –3 as the seed value for *X*.)

In some situations, the Solve app will use a random number seed in its search for a solution. This means that is it not always predictable which seed will lead to which solution when there are multiple solutions.

Solution information

When you are solving a single equation, the Info button appears on the menu after you tap Solve. Tapping Info displays a message giving you some information about the solutions found (if any). Tap OK to clear the message.

Message	Meaning
`Zero`	The Solve app found a point where both sides of the equation were equal, or where the expression was zero (a root), within the calculator's 12-digit accuracy.
`Sign Reversal`	Solve found two points where the two sides of the equation have opposite signs, but it cannot find a point in between where the value is zero. Similarly, for an expression, where the value of the expression has different signs but is not precisely zero. This might be be cause either the two points are neighbours (they differ by one in the twelfth digit), or the equation is not real-valued between the two points. Solve returns the point where the value or difference is closer to zero. If the equation or expression is continuously real, this point is Solve’s best approximation of an actual solution.
`Extremum`	Solve found a point where the value of the expression approximates a local minimum (for positive values) or maximum (for negative values). This point may or may not be a solution. Or: Solve stopped searching at 9.99999999999E499, the largest number the calculator can represent. Note that the `Extremum` message indicates that it is highly likely that there is no solution. Use Numeric view to verify this (and note that any values shown are suspect).
`Cannot find solution`	No values satisfy the selected equation or expression.

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

13

Linear Solver app

The Linear Solver app enables you to solve a set of linear equations. The set can contain two or three linear equations.

In a two-equation set, each equation must be in the form $ax + by = k$. In a three-equation set, each equation must be in the form $ax + by + cz = k$.

You provide values for *a*, *b*, and *k* (and *c* in three-equation sets) for each equation, and the app will attempt to solve for *x* and *y* (and *z* in three-equation sets).

The HP Prime will alert you if no solution can be found, or if there is an infinite number of solutions.

Getting started with the Linear Solver app

The following example defines the following set of equations and then solves for the unknown variables:

$$6x + 9y + 6z = 5$$

$$7x + 10y + 8z = 10$$

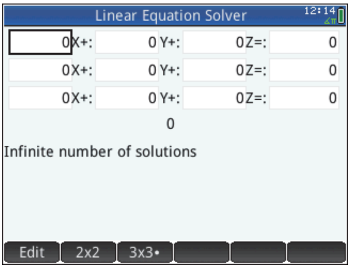
$$6x + 4y = 6$$

Open the Linear Solver app

1. Open the Linear Solver app.

   Apps Info Select `Linear Solver`

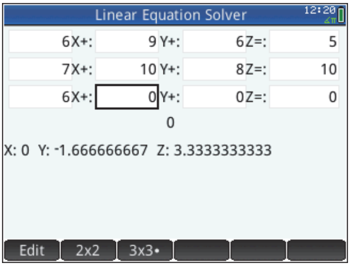
   The app opens in Numeric view.



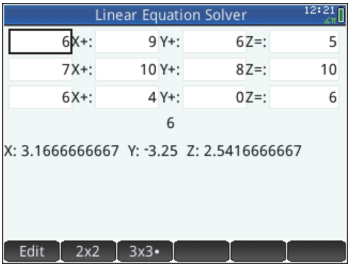
Note If the last time you used the Linear Solver app you solved for two equations, the two-equation input form is displayed. To solve a three-equation set, tap 3x3; now the input form displays three equations.

Define and solve the equations

2. You define the equations you want to solve by entering the coefficients of each variable in each equation and the constant term. Notice that the cursor is positioned immediately to the left of *x* in the first equation, ready for you to insert the coefficient of *x* (6). Enter the coefficient and either tap OK or press Enter.
3. The cursor moves to the next coefficient. Enter that coefficient and either tap OK or press Enter. Continue doing likewise until you have defined all the equations.



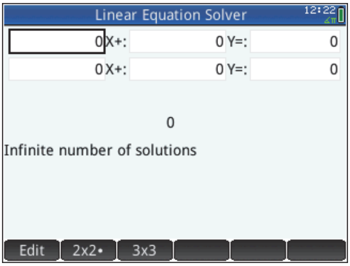
Once you have entered enough values for the solver to be able to generate solutions, those solutions appear near the bottom of the display. In this example, the solver was able to find solutions for *x*, *y*, and *z* as soon as the first coefficient of the last equation was entered.



As you enter each of the remaining known values, the solution changes. The graphic at the right shows the final solution once all the coefficients and constants had been entered.

Solve a two-by-two system

If the three-equation input form is displayed and you want to solve a two-equation set, tap 2x2.



Note You can enter any expression that resolves to a numerical result, including variables. Just enter the name of a variable. For more information on assigning values to variables, see “Storing a value in a variable” on page 39.

Menu items

The menu items are:

- Edit: moves the cursor to the entry line where you can add or change a value. You can also highlight a field, enter a value, and press Enter. The cursor automatically moves to the next field, where you can enter the next value and press Enter.
- 2x2: displays the page for solving a system of 2 linear equations in 2 variables; changes to 2x2• when active
- 3x3: displays the page for solving a system of 3 linear equations in 3 variables; changes to 3x3• when active

14

Parametric app

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

Getting started with the Parametric app

The Parametric app uses the customary app views: Symbolic, Plot and Numeric described in chapter 4.

For a description of the menu buttons available in this app, see:

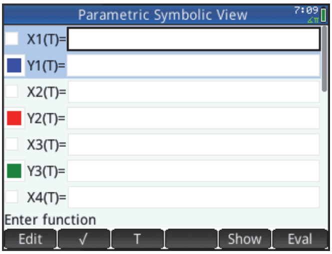
- "Symbolic view: Summary of menu buttons" on page 76
- "Plot view: Summary of menu buttons" on page 86, and
- "Numeric view: Summary of menu buttons" on page 94

Throughout this chapter, we will explore the parametric equations *x*(*T*) = 8sin(*T*) and *y*(*T*) = 8cos(*T*). These equations produce a circle.

Open the Parametric app

1. Open the Parametric app.

   Apps Info Select `Parametric`



   The Parametric app starts in Symbolic view. This is the *defining view*. It is where you symbolically define (that is, specify) the parametric expressions you want to explore.

The graphical and numerical data you see in Plot view and Numeric view are derived from the symbolic functions defined here.

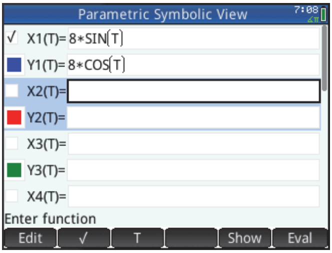
Define the functions

There are 20 fields for defining functions. These are labelled `X1(T)` through `X9(T)` and `X0(T)`, and `Y1(T)` through `Y9(T)` and `Y0(T)`. Each X function is paired with a Y function.

2. Highlight which pair of functions you want to use, either by tapping on, or scrolling to, one of the pair. If you are entering a new function, just start typing. If you are editing an existing function, tap Edit and make your changes. When you have finished defining or changing the function, press Enter.

3. Define the two expressions.

   8 SIN xtθn Enter
   8 COS xtθn Enter



   Notice how the xtθn key enters whatever variable is relevant to the current app. In the Function app, xtθn enters an X. In the Parametric app it enters a T. In the Polar app, discussed in chapter 15, it enters θ.

4. Decide if you want to:

   – give one or more function a custom color when it is plotted

   – evaluate a dependent function

   – deselect a definition that you don’t want to explore

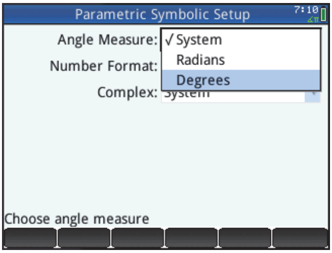
   – incorporate variables, math commands and CAS commands in a definition.

   For the sake of simplicity we can ignore these operations in this example. However, they can be useful and are described in detail in “Common operations in Symbolic view” on page 71.

Set the angle measure

Set the angle measure to degrees:

5. Shift Symb (Settings)



6. Tap the **Angle Measure** field and select `Degrees`.

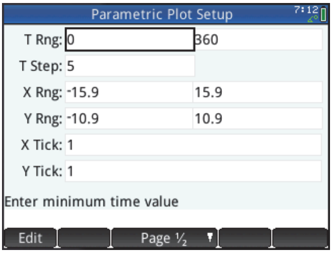
   You could also have set the angle measure on the **Home Settings** screen. However, Home settings are system-wide. By setting the angle measure in an app rather than Home view, you are limiting the setting just to that app.

Set up the plot

7. Open the Plot Setup view:

   Shift Plot (Setup)

8. Set up the plot by specifying appropriate graphing options. In this example, set the **T Rng** and **T Step** fields so that *T* steps from 0° to 360° in 5° steps:



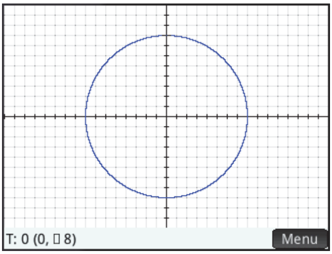
   Select the 2nd **T Rng** field and enter:

   360 OK 5 OK

Plot the functions

9. Plot the functions:

   Plot



Explore the graph

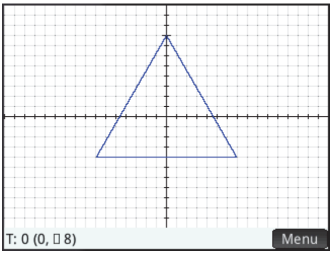
The menu button gives you access to common tools for exploring plots:

> **Zoom**: displays a range of zoom options. (The **+** and **−** keys can also be used to zoom in and out.)
>
> **TRACE•**: when active, enables a tracing cursor to be moved along the contour of the plot (with the coordinates of the cursor displayed at the bottom of the screen).
>
> **Go To**: specify a `T` value and the cursor moves to the corresponding x and y coordinates.
>
> **Defn**: display the functions responsible for the plot.

Detailed information about these tools is provided in “Common operations in Plot view” on page 77.

Typically you would modify a plot by changing its definition in Symbolic view. However, you can modify some plots by changing the Plot Setup parameters. For example, you can plot a triangle instead of a circle simply by changing two plot setup parameters. The definitions in Symbolic view remain unchanged. Here is how it is done:

10. Press **Shift** **Plot** (Setup).
11. Change **T Step** to 120.
12. Tap **Page ½**.
13. From the **Method** menu, select `Fixed-Step Segments`.
14. Press **Plot**.



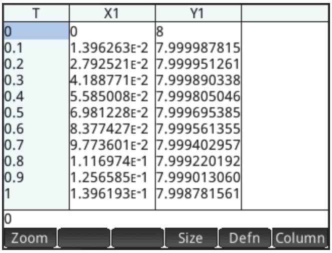
A triangle is displayed instead of a circle. This is because the new value of **T Step** makes the points being plotted 120° apart instead of the nearly continuous 5°. And by selecting `Fixed-Step Segments` the points 120° apart are connected with line segments.

Display the numeric view

15. Display the Numeric view:

    Num Setup

16. With the cursor in the `T` column, type a new value and tap OK. The table scrolls to the value you entered.



You can also zoom in or out on the independent variable (thereby decreasing or increasing the increment between consecutive values). This and other options are explained in "Common operations in Numeric view" on page 90.

You can see the Plot and Numeric views side by side. See "Combining Plot and Numeric Views" on page 96.

15

Polar app

The Polar app enables you to explore polar equations. Polar equations are equations in which *r*—the distance a point is from the origin: (0,0)—is defined in terms of θ, the angle a segment from the point to the origin makes with the polar axis. Such equations take the form $r = f(\theta)$.

Getting started with the Polar app

The Polar app uses the six standard app views described in chapter 4, "An introduction to HP apps", beginning on page 59. That chapter also describes the menu buttons used in the Polar app.

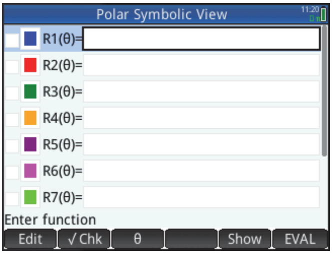
Throughout this chapter, we will explore the expression `5πcos(θ/2)cos(θ)`^{2}.

Open the Polar app

1. Open the Polar app:

   Apps Info Select `Polar`

   The app opens in Symbolic view.

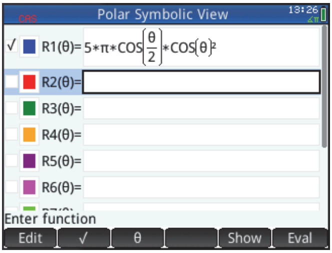


Define the function

There are 10 fields for defining polar functions. These are labelled `R1(θ)` through `R9(θ)` and `R0(θ)`.

2. Highlight the field you want to use, either by tapping on it or scrolling to it. If you are entering a new function, just start typing. If you are editing an existing function, tap Edit and make your changes. When you have finished defining or changing the function, press Enter.
3. Define the expression `5πcos(θ/2)cos(θ)`^{2}.

5 Shift 3 COS xtθn ÷ 2 ▶ ▶ COS xtθn ▶ x² Enter



Notice how the xtθn key enters whatever variable is relevant to the current app. In this app the relevant variable is θ.

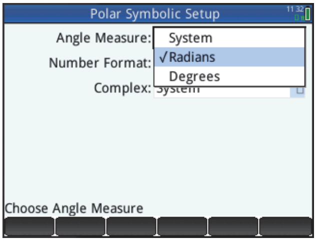
4. If you wish, choose a color for the plot other than its default. You do this by selecting the colored square to the left of the function set, tapping Choose, and selecting a color from the color-picker.

For more information about adding definitions, modifying definitions, and evaluating dependent definitions in Symbolic view, see "Common operations in Symbolic view" on page 71.

Set angle measure

Set the angle measure to radians:

5. Shift Symb (Settings)



6. Tap the **Angle Measure** field and select `Radians`.

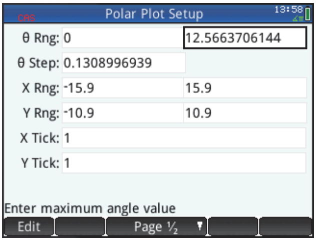
For more information on the Symbolic Setup view, see "Common operations in Symbolic Setup view" on page 76.

Set up the plot

7. Open the Plot Setup view:

   Shift Plot (Setup)

8. Set up the plot by specifying appropriate graphing options. In this example, set the upper limit of the range of the independent variable to 4π:



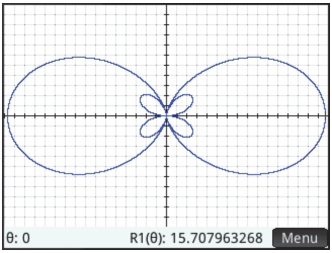
Select the 2nd θ **Rng** field and enter 4 Shift 3 (π) OK

There are numerous ways of configuring the appearance of Plot view. For more information, see "Common operations in Plot Setup view" on page 86.

Plot the expression

9. Plot the expression:

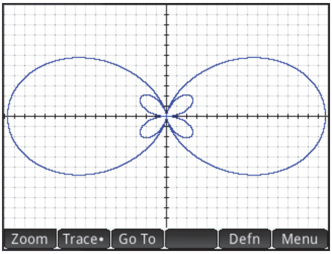
Plot Setup



Explore the graph

10. Display the Plot view menu.

Menu



A number of options appear to help you can explore the graph, such as zoom and trace options. using the trace and zoom options. You can also jump directly to a particular θ value by entering that value. The **Go To** screen appears with the number you typed on the entry line. Just tap OK to accept it. (You could also tap the Go To button and spwecify the target value.)

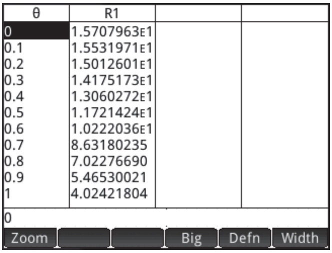
If only one polar equation is plotted, you can see the equation that generated the plot by tapping Defn. If there are several equations plotted, move the tracing cursor to the plot you are interested—by pressing ▲ or ▼—and then tap Defn.

For more information on exploring plots in Plot view, see “Common operations in Plot view” on page 77.

Display the Numeric view

11. Open the Numeric view:

    Num Setup



θ	R1		
0	1.5707963E1		
0.1	1.5531971E1		
0.2	1.5012601E1		
0.3	1.4175173E1		
0.4	1.3060272E1		
0.5	1.1721424E1		
0.6	1.0222036E1		
0.7	8.63180235		
0.8	7.02276690		
0.9	5.46530021		
1	4.02421804		

    The Numeric view displays a table of values for θ and R1. If you had specified, and selected, more than one polar function in Symbolic view, a column of evaluations would appear for each one: R2, R3, R4 and so on.

12. With the cursor in the θ column, type a new value and tap OK. The table scrolls to the value you entered.

You can also zoom in or out on the independent variable (thereby decreasing or increasing the increment between consecutive values). This and other options are explained in “Common operations in Numeric view” on page 90.

You can see the Plot and Numeric views side by side. See “Combining Plot and Numeric Views” on page 96.

16

Sequence app

The Sequence app provides you with various ways to explore sequences.

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

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

You can define a sequence by specifying just the first term and the rule for generating all subsequent terms. However, you will have to enter the second term if the HP Prime is unable to calculate it automatically. Typically if the *n*th term in the sequence depends on $n-2$, then you must enter the second term.

The app enables you to create two types of graphs:

- a **Stairsteps** graph, which plots n on the horizontal axis and U_n on the vertical axis
- a **Cobweb** graph, which plots U_{n-1} on the horizontal axis and U_n on the vertical axis.

Getting started with the Sequence app

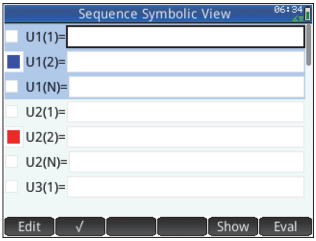
The following example explores the well-known Fibonacci sequence, where each term, from the third term on, is the sum of the preceding two terms. In this example, we specify three sequence fields: the first term, the second term and a rule for generating all subsequent terms.

Open the Sequence app

1. Open the Sequence app:

   Apps Info Select `Sequence`

   The app opens in Symbolic view.



Define the expression

2. Define the Fibonacci sequence:

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

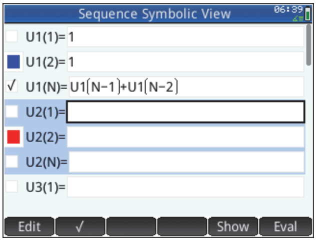
   In the U1(1) field, specify the first term of the sequence:

   1 Enter

   In the U1(2) field, specify the second term of the sequence:

   1 Enter

   In the U1(N) field, specify the third term of the sequence (using the buttons at the bottom of the screen to help with some entries):



   U1 (N−1) +
   U1 (N−2) Enter

3. Optionally choose a color for your graph (see “Choose a color for plots” on page 74).

Set up the plot

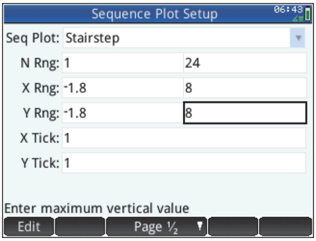
4. Open the Plot Setup view:

   Shift Plot (Setup)

5. Reset all settings to their default values:

   Shift Esc (Clear)

6. Select `Stairstep` from the **Seq Plot** menu.

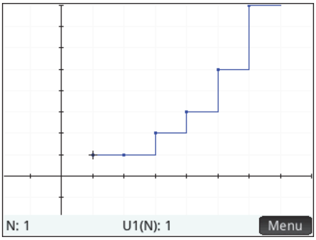


7. Set the **X Rng** maximum, and the **Y Rng** maximum, to 8 (as shown at the right).

Plot the sequence

8. Plot the Fibonacci sequence:

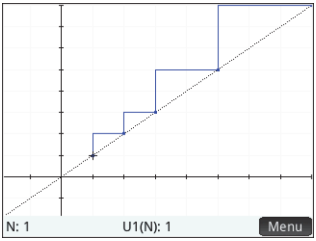
   Plot Setup



9. Return to Plot Setup view (Shift Plot Setup) and select `Cobweb`, from the **Seq Plot** menu.

10. Plot the sequence:

    Plot Setup



Explore the graph

The Menu button gives you access to common plot-exploration tools, such as:

- Zoom in or out on the plot: Zoom
- Trace along a graph: Trace•
- Go to a specified N value: Go To
- Display the sequence definition: Defn

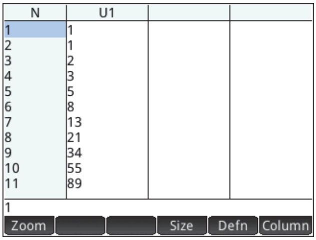
These tools are explained in “Common operations in Plot view” on page 77.

Split screen and autoscaling functionality is also available by pressing View Copy.

Display Numeric view

11. Display Numeric view:

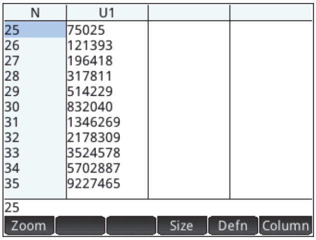
    Num Setup



N	U1		
1	1		
2	1		
3	2		
4	3		
5	5		
6	8		
7	13		
8	21		
9	34		
10	55		
11	89		

12. With the cursor anywhere in the **N** column, type a new value and tap OK.

    The table of values scrolls to the value you entered. You can then see the corresponding value in the sequence. The example at the right shows that the 25th value in the Fibonacci sequence is 75,025.



N	U1		
25	75025		
26	121393		
27	196418		
28	317811		
29	514229		
30	832040		
31	1346269		
32	2178309		
33	3524578		
34	5702887		
35	9227465		

Explore the table of values

The Menu button gives you access to common table-exploration tools, such as:

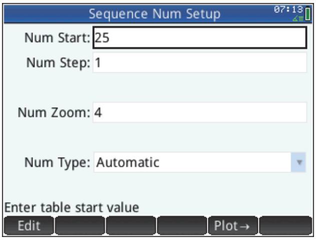
- Change the increment between consecutive values: Zoom
- Change the size of the font: Size
- Display the sequence definition: Defn
- Choose the number of sequences to display: Column

  These tools are explained in “Common operations in Numeric view” on page 90.

  Split screen and autoscaling functionality is also available by pressing View Copy.

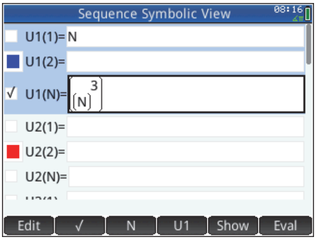
Set up the table of values

The Numeric Setup view provides options common to most of the graphing apps. See “Common operations in Numeric Setup view” on page 95 for more information.



Another example: A table of cubes

In the following example, a table of cubes is created. Note that if you are specifying two starting terms (as in the Fibonacci example above) or one (as in the example at the right, the rule that generates the sequence must be placed in the **U_n(N)** field.



17

Finance app

The Finance app enables you to solve time-value-of-money (TVM) and amortization problems. You can use the app to do compound interest calculations and to create amortization tables.

Compound interest is accumulative interest, that is, interest on interest already earned. The interest earned on a given principal is added to the principal at specified compounding periods, and then the combined amount earns interest at a certain rate. Financial calculations involving compound interest include savings accounts, mortgages, pension funds, leases, and annuities.

Getting Started with the Finance app

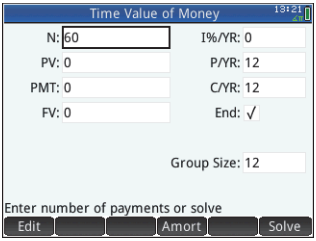
Suppose you finance the purchase of a car with a 5-year loan at 5.5% annual interest, compounded monthly. The purchase price of the car is $19,500, and the down payment is $3,000. First, what are the required monthly payments? Second, what is the largest loan you can afford if your maximum monthly payment is $300? Assume that the payments start at the end of the first period.

1. Start the Finance app.

   Apps Info Select `Finance`

   The app opens in the Numeric view.

2. In the **N** field, enter 5 × 12 and press Enter.

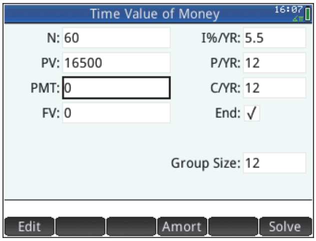
   

   Notice that the result of the calculation (60) appears in the field. This is the number of months over a five-year period.

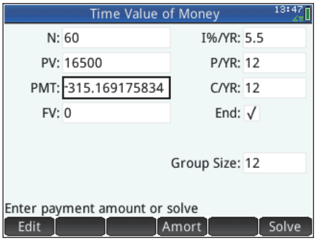
3. In the `I%/YR` field, type 5.5—the interest rate—and press Enter.

4. In `PV` field, type 19500 – 3000 and press Enter. This is the present value of the loan, being the purchase price less the deposit.

5. Leave `P/YR` and `C/YR` both at `12` (their default values). Leave `End` as the payment option. Also, leave future value, `FV`, as `0` (as your goal is to end up with a future value of the loan of 0).



6. Move the cursor to the `PMT` field and tap Solve. The PMT value is calculated as –315.17. In other words, your monthly payment will be $315.17.

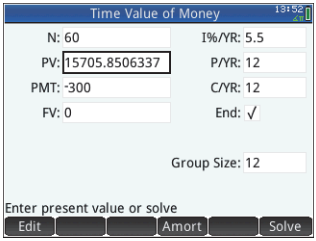


   The PMT value is negative to indicate that it is money owed by you.

   Note that the PMT value is greater than 300, that is, greater than the amount you can afford to pay each month. So you ned to re-run the calculations, this time setting the PMT value to –300 and calculating a new PV value.

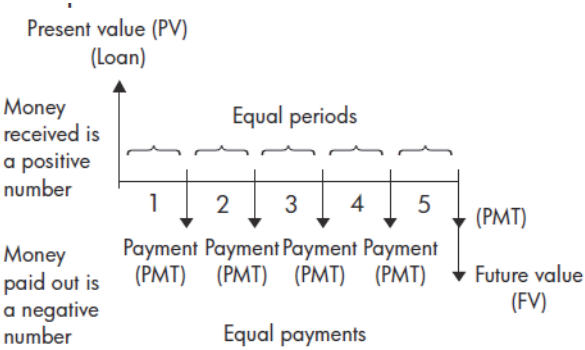
7. In the `PMT` field, enter +/– 300 move the cursor to the `PV` field, and tap Solve.

The PV value is calculated as 15,705.85, this being the maximum you can borrow. Thus, with your $3,000 deposit, you can afford a car with a price tag of up to $18,705.85.

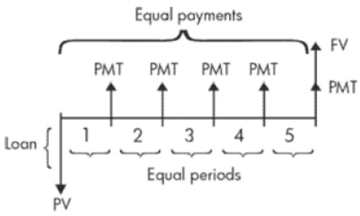


Cash flow diagrams

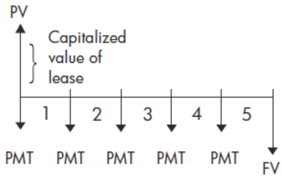
TVM transactions can be represented in *cash flow diagrams*. A cash flow diagram is a time line divided into equal segments representing the compounding periods. Arrows represent the cash flows. These could be positive (upward arrows) or negative (downward arrows), depending on the point of view of the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



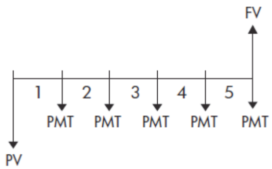
The following cash flow diagram shows a loan from the *lender's* point of view:



Cash flow diagrams also specify *when* payments occur relative to the compounding periods.The diagram to the right shows lease payments at the *beginning* of the period.



This diagram shows deposits (PMT) into an account at the end of each period.



Time value of money (TVM)

Time-value-of-money (TVM) calculations make use of the notion that a dollar today will be worth more than a dollar sometime in the future. A dollar today can be invested at a certain interest rate and generate a return that the same dollar in the future cannot. This TVM principle underlies the notion of interest rates, compound interest, and rates of return. There are seven TVM variables:

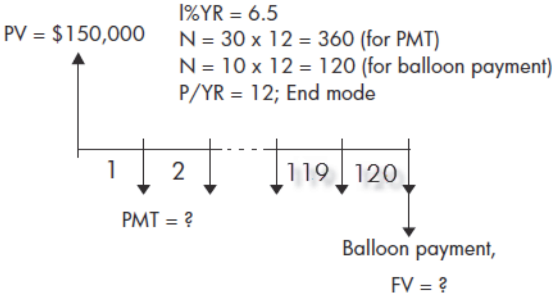
Variable	Description
N	The total number of compounding periods or payments.

I%YR	The nominal annual interest rate (or investment rate). This rate is divided by the number of payments per year (P/YR) to compute the nominal interest rate *per compounding period*. This is the interest rate actually used in TVM calculations.
PV	The present value of the initial cash flow. To a lender or borrower, PV is the amount of the loan; to an investor, PV is the initial investment. PV always occurs at the beginning of the first period.
P/YR	The number of payments made in a year.
PMT	The periodic payment amount. The payments are the same amount each period and the TVM calculation assumes that no payments are skipped. Payments can occur at the beginning or the end of each compounding period—an option you control by un-checking or checking the `End` option.
C/YR	The number of compounding periods in a year.
FV	The future value of the transaction: the amount of the final cash flow or the compounded value of the series of previous cash flows. For a loan, this is the size of the final balloon payment (beyond any regular payment due). For an investment, this is its value at the end of the investment period.

TVM calculations: Another example

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

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



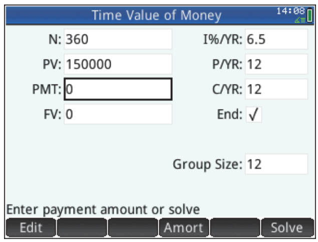
1. Start the Finance app:

   Apps Info Select `Finance`

2. Return all fields to their default values:

   Shift Esc Clear

3. Enter the known TVM variables, as shown in the figure.



4. Highlight `PMT` and tap Solve. The `PMT` field shows –984.10. In other words, the monthly payments are $948.10.

5. To determine the balloon payment or future value (FV) for the mortgage after 10 years, enter 120 for `N`, highlight `FV`, and tap Solve.

   The `FV` field shows –127,164.19, indicating that the future value of the loan (that is, how much is still owing) as $127,164.19.

Calculating amortizations

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

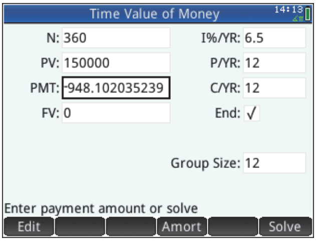
To calculate amortizations:

1. Start the Finance app.
2. Specify the number of payments per year (P/YR).
3. Specify whether payments are made at the beginning or end of periods.
4. Enter values for I%YR, PV, PMT, and FV.
5. Enter the number of payments per amortization period in the Group Size field. By default, the group size is 12 to reflect annual amortization.
6. Tap **Amort**. The calculator displays an amortization table. For each amortization period, the table shows the amounts applied to interest and principal, as well as the remaining balance of the loan.

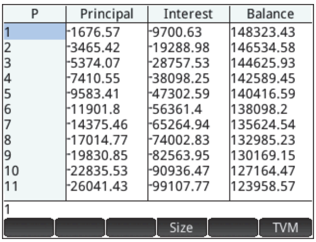
Example: Amortization for a home mortgage

Using the data from the previous example of a home mortgage with balloon payment (see page 267), calculate how much has been applied to the principal, how much has been paid in interest, and the balance remaining after the first 10 years (that is, after 12 × 10 = 120 payments).

1. Make your data match that shown in the figure to the right.



2. Tap **Amort**.

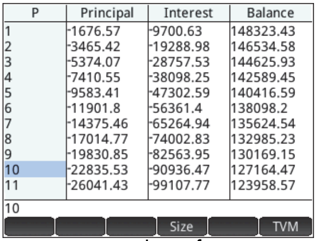


P	Principal	Interest	Balance
1	-1676.57	-9700.63	148323.43
2	-3465.42	-19288.98	146534.58
3	-5374.07	-28757.53	144625.93
4	-7410.55	-38098.25	142589.45
5	-9583.41	-47302.59	140416.59
6	-11901.8	-56361.4	138098.2
7	-14375.46	-65264.94	135624.54
8	-17014.77	-74002.83	132985.23
9	-19830.85	-82563.95	130169.15
10	-22835.53	-90936.47	127164.47
11	-26041.43	-99107.77	123958.57

1

Size TVM

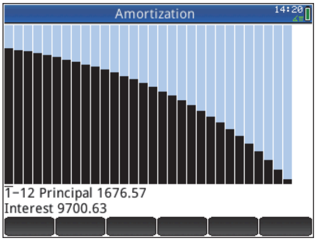
3. Scroll down the table to payment group 10. Note that after 10 years, $22,835.53 has been paid off the principal and $90,936.47 paid in interest, leaving a balloon payment due of $127,164.47.



P	Principal	Interest	Balance
1	-1676.57	-9700.63	148323.43
2	-3465.42	-19288.98	146534.58
3	-5374.07	-28757.53	144625.93
4	-7410.55	-38098.25	142589.45
5	-9583.41	-47302.59	140416.59
6	-11901.8	-56361.4	138098.2
7	-14375.46	-65264.94	135624.54
8	-17014.77	-74002.83	132985.23
9	-19830.85	-82563.95	130169.15
10	-22835.53	-90936.47	127164.47
11	-26041.43	-99107.77	123958.57

Amortization graph

Press Plot to see the amortization schedule presented graphically. The balance owing at the end of each payment group is indicated by the height of a bar. The amount by which the principal has been reduced, and interest paid, during a payment group is shown at the bottom of the bottom of the screen. The example at the right shows the first payment group selected. This represents the first group of 12 payments (or the state of the loan at the end of the first year). By the end of that year, the principal had been reduced by $1,676.57 and $9,700.63 had been paid in interest.



Tap ▶ or ◀ to see the amount by which the principal has been reduced, and interest paid, during other payment groups.

18

Triangle Solver app

The Triangle Solver app enables you to calculate the length of a side of a triangle, or the size of an angle in a triangle, from information you supply about the other lengths, angles, or both.

You need to specify at least three of the six possible values—the lengths of the three sides and the size of the three angles—before the app can calculate the other values. Moreover, at least one value you specify must be a length. For example, you could specify the lengths of two sides and one of the angles; or you could specify two angles and one length; or all three lengths. In each case, the app will calculate the remaining values.

The HP Prime will alert you if no solution can be found, or if you have provided insufficient data.

If you are determining the lengths and angles of a *right-angled* triangle, a simpler input form is available by tapping Rect.

Getting started with the Triangle Solver app

The following example calculates the unknown length of the side of a triangle whose two known sides—of lengths 4 and 6—meet at an angle of 30 degrees.

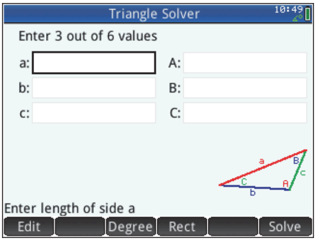
Open the Triangle Solver app

1. Open the Triangle Solver app.

   Apps Info Select

   `Triangle Solver`

   The app opens in Numeric view.



2. If there is unwanted data from a previous calculation, you can clear it all by pressing Shift Esc Clear (Clear).

Set angle measure

Make sure that your angle measure mode is appropriate. By default, the app starts in degree mode. If the angle information you have is in radians and your current angle measure mode is degrees, change the mode to degrees before running the solver. Tap Degree or Radians depending on the mode you want. (The button is a toggle button.)

Note The lengths of the sides are labeled **a**, **b**, and **c**, and the angles are labeled **A**, **B**, and, **C**. It is important that you enter the known values in the appropriate fields. In our example, we know the length of two sides and the angle at which those sides meet. Hence if we specify the lengths of sides **a** and **b**, we must enter the angle as **C** (since **C** is the angle where **A** and **B** meet). If instead we entered the lengths as **b** and **c**, we would need to specify the angle as **A**. The illustration on the screen will help you determine where to enter the known values.

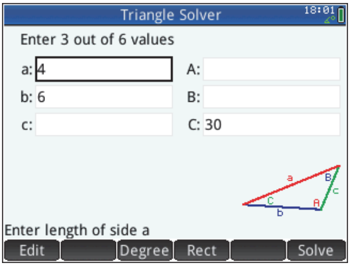
Specify the known values

3. Go to a field whose value you know, enter the value and either tap OK or press Enter. Repeat for each known value.

(a). In **a** type 4 and press Enter.

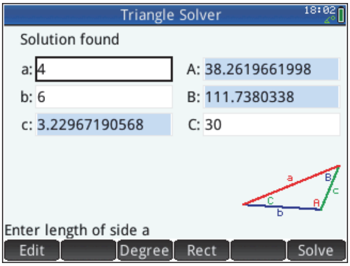
(b). In **b** type 6 and press Enter.

(c). In **C** type 30 and press Enter.

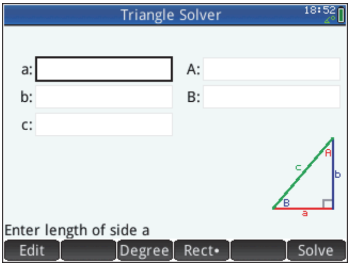


Solve for the unknown values

4. Tap Solve. The app displays the values of the unknown variables. As the illustration at the right shows, the length of the unknown side in our example is 3.22967… The other two angles have also been calculated.



Choosing triangle types



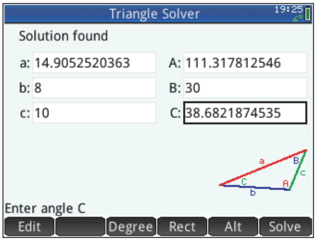
The Triangle Solver app has two input forms: a general input form and a simpler, specialized form for right-angled triangles. If the general input form is displayed, and you are investigating a right-angled triangle, tap Rect to display the simpler input form. To return to the general input form, tap Rect•. If the triangle you are investigating is not a right-angled triangle, or you are not sure what type it is, you should use the general input form.

Special cases

The indeterminate case

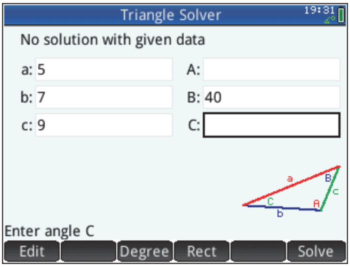
If two sides and an adjacent acute angle are entered and there are two solutions, only one will be displayed initially.

In this case, the **Alt** button is displayed (as in this example). You can tap **Alt** to display the second solution and tap **Alt** again to return to the first solution.



No solution with given data

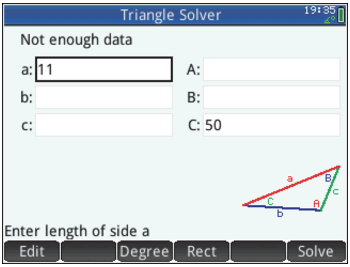
If you are using the general input form and you enter more than 3 values, the values might not be consistent, that is, no triangle could possibly have all the values you specified. In these cases, `No sol with given data` appears on the screen.



The situation is similar if you are using the simpler input form (for a right-angled triangle) and you enter more than two values.

Not enough data

If you are using the general input form, you need to specify at least three values for the Triangle Solver to be able to calculate the remaining attributes of the triangle. If you specify less than three, `Not enough data` appears on the screen.



If you are using the simplified input form (for a right-angled triangle), you must specify at least two values.

19

The Explorer apps

There are three explorer apps. These are designed for you to explore the relationships between the parameters of a function and the shape of the graph of that function. The explorer apps are:

- Linear Explorer

  For exploring linear functions
- Quadratic Explorer

  For exploring quadratic functions
- Trig Explorer

  For exploring sinusoidal functions

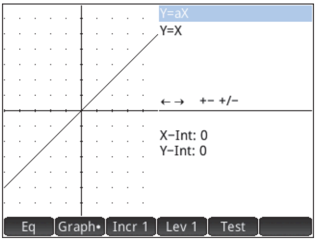
There are two modes of exploration: graph mode and equation mode. In graph mode you manipulate a graph and note the corresponding changes in its equation. In equation mode you manipulate an equation and note the corresponding changes in its graphical representation. Each explorer app has a number of equations and graphs for to explore, and app has a test mode. In test mode, you test you skills at matching equations to graphs.

Linear Explorer app

The Linear Explorer app can be used to explore the behavior of the graphs of $y = ax$ and $y = ax + b$ as the values of a and b change.

Open the app

Press Apps Info and select `Linear Explorer`.



The left half of the display shows the graph of a linear function. The right half shows the general form of the equation being explored at the top and, below it, the current equation of that form. The keys you can use to manipulate the graph or equation appear below the equation. The x- and y-intercepts are given at the bottom.

There are two types (or levels) of linear equation available for you to explore: y = ax and y = ax + b. You choose between them by tapping Lev 1 or Lev 2.

The keys available to you to manipulate the graph or equation depend on the level you have chosen. For example, the screen for a level 1 equation shows this:

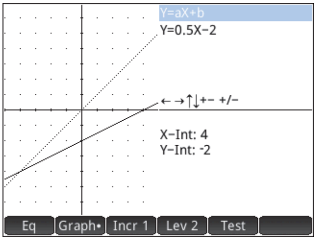
←→ +− +/−

This means that you can press ◀, ▶, [+], [−] and [+/−]. If you choose a level 2 equation, the screen shows this:

←→↑↓+− +/−

This means that you can press ◀, ▶, ▲, ▼, [+], [−] and [+/−].

Graph mode

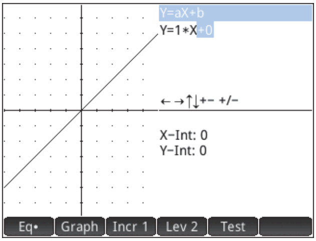


The app opens in graph mode (indicated by the dot on the `Graph` button at the bottom of the screen). In graph mode, the ▲ and ▼ keys translate the graph vertically, effectively changing the y-intercept of the line. Tap Incr 1 to change the magnitude of the increment for vertical translations. The ◀ and ▶ keys (as well as [−] and [+]) decrease and increase the slope. Press [+/−] to change the sign of the slope.

The form of the linear function is shown at the top right of the display, with the current equation that matches the graph just below it. As you manipulate the graph, the equation updates to reflect the changes.

Equation mode

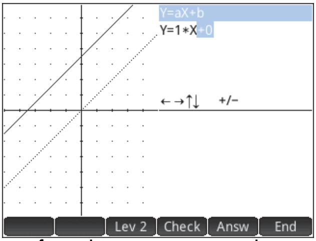
Tap Eq to enter equation mode. A dot will appear on the `Eq` button at the bottom of the screen.



In equation mode, you use the cursor keys to move between parameters in the equation and change their values, observing the effect on the graph displayed. Press ▼ or ▲ to decrease or increase the value of the selected parameter. Press ▶ or ◀ to select another parameter. Press +/− to change the sign of *a*.

Test mode

Tap Test to enter test mode. In Test mode you test your skill at matching an equation to the graph shown. Test mode is like equation mode in that you use the cursor keys to select and change the value of each parameter in the equation. The goal is to try to match the graph that is shown.



The app displays the graph of a randomly chosen linear function of the form dictated by your choice of level. (Tap Lev 1 or Lev 2 to change the level.) Now press the cursor keys to select a parameter and set its value. When you are ready, tap Check to see if you have correctly matched your equation to the given graph.

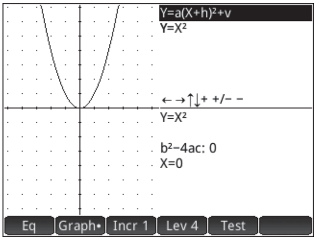
Tap Answ to see the correct answer and tap End to exit Test mode.

Quadratic Explorer app

The Quadratic Explorer app can be used to investigate the behavior of $y = a(x+h)^2 + v$ as the values of *a*, *h* and *v* change.

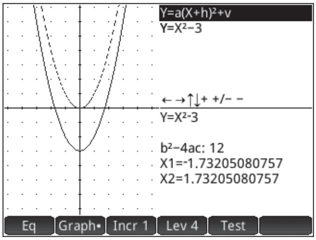
Open the app

Press Apps Info and select `Quadratic Explorer`.



The left half of the display shows the graph of a quadratic function. The right half shows the general form of the equation being explored at the top and, below it, the current equation of that form. The keys you can use to manipulate the graph or equation appear below the equation. (These will change depending on the level of equation you choose.) Displayed beneath they keys is the equation, the discriminant (that is, b^2-4ac), and the roots of the quadratic.

Graph mode



The app opens in graph mode. In graph mode, you manipulate a copy of the graph using whatever keys are available. The original graph—converted to dotted lines—remains in place for you to easily see the result of your manipulations.

Four general forms of quadratic equations are available for you to explore:

$y = ax^2$ [Level 1]

$y = (x+h)^2$ [Level 2]

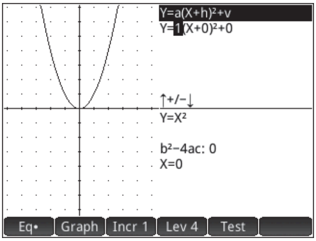
$y = x^2+v$ [Level 3]

$y = a(x+h)^2+v$ [Level 4]

Choose a general form by tapping the Level button— Lev 1 , Lev 2 and so on—until the form you want is displayed. The keys available to you to manipulate the graph vary from level to level.

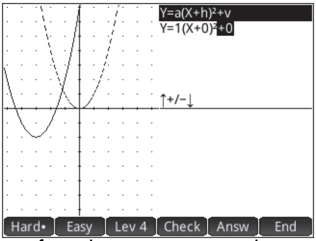
Equation mode

Tap Eq to move to equation mode. In equation mode, you use the cursor keys to move between parameters in the equation and change their values, observing the effect on the graph displayed. Press ▼ or ▲ to decrease or increase the value of the selected parameter. Press ▶ or ◀ to select another parameter. Press +/− to change the sign. You have four forms (or levels) of graph, and the keys available for manipulating the equation depend on the level chosen.



Test mode

Tap Test to enter test mode. In Test mode you test your skill at matching an equation to the graph shown. Test mode is like equation mode in that you use the cursor keys to select and change the value of each parameter in the equation. The goal is to try to match the graph that is shown.



The app displays the graph of a randomly chosen quadratic function. Tap the Level button to choose between one of four forms of quadratic equation. You can also choose graphs that are relatively easy to match or graphs that are harder match (by tapping Easy or Hard respectively).

Now press the cursor keys to select a parameter and set its value. When you are ready, tap Check to see if you have correctly matched your equation to the given graph.

Tap Answ to see the correct answer and tap End to exit Test mode.

Trig Explorer app

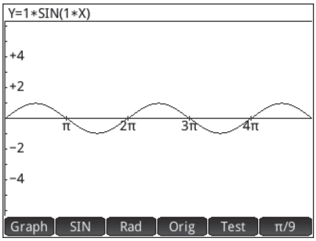
The Trig Explorer app can be used to investigate the behavior of the graphs $y = a \cdot \sin(bx + c) + d$ and $y = a \cdot \cos(bx + c) + d$ as the values of *a*, *b*, *c* and *d* change.

The menu items available in this app are:

- Eq or Graph: toggles between graph mode and equation mode
- SIN or COS: toggles between sine and cosine graphs
- Rad or Deg: toggles between radians and degrees as the angle measure for *x*
- Orig or Extr: toggles between translating the graph (Orig), and changing its frequency or amplitude (Extr). You make these changes using the cursor keys.
- Test: enters test mode
- π/9 or 20°: toggles the increment by which parameter values change: π/9, π/6, π/4, or 20°, 30°, 45° (depending on angle measure setting)

Open the app

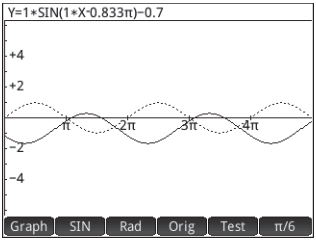
Press Apps Info and select `Trig Explorer`.



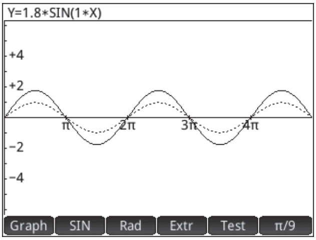
An equation is shown at the top of the display, with its graph shown below it.

Choose the type of function you want to explore by tapping either COS or SIN.

Graph mode



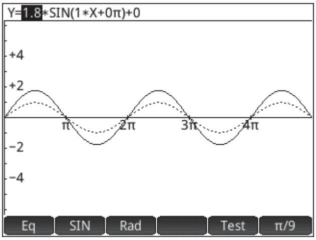
The app opens in graph mode. In graph mode, you manipulate a copy of the graph by pressing the cursor keys. All four keys are available. The original graph—converted to dotted lines—remains in place for you to easily see the result of your manipulations.



When Orig is chosen, the cursor keys simply translate the graph horizontally and vertically. When Extr is chosen, pressing ▲ or ▼ changes the *amplitude* of the graph (that is, it is stretched or shrunk vertically); and pressing ◄ or ► changes the *frequency* of the graph (that is, it is stretched or shrunk horizontally).

The π/9 or 20° button at the far right of the menu determines the increment by which the graph moves with each press of a cursor key. By default, the increment is set at $\pi/9$ or 20°.

Equation mode



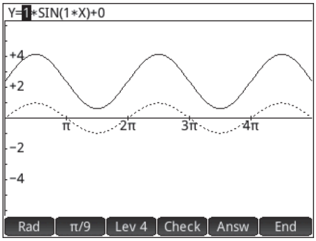
Tap Graph to switch to equation mode. In equation mode, you use the cursor keys to move between parameters in the equation and change their values. You can then observe the effect on the graph displayed. Press ▼ or ▲ to decrease or increase the value of the selected parameter. Press ► or ◄ to select another parameter.

You can switch back to graph mode by tapping Eq.

Test mode

Tap Test to enter test mode. In test mode you test your skill at matching an equation to the graph shown. Test mode is like equation mode in that you use the cursor keys to select and change the value of one or more parameters in the equation. The goal is to try to match the graph that is shown.

The app displays the graph of a randomly chosen sinusoidal function. Tap a Level button—Lev 1, Lev 2 and so on—to choose between one of five types of sinusoidal equations.



Now press the cursor keys to select each parameter and set its value. When you are ready, tap Check to see if you have correctly matched your equation to the given graph.

Tap Answ to see the correct answer and tap End to exit Test mode.

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Functions and commands

Many mathematical functions are available from the calculator's keyboard. These are described in "Keyboard functions" on page 285. Other functions and commands are collected together in the Toolbox menus (Mem B). There are five Toolbox menus:

- **Math**

  A collection of non-symbolic mathematical functions (see "Keyboard functions" on page 285)

- **CAS**

  A collection of symbolic mathematical functions (see "CAS menu" on page 298)

- **App**

  A collection of app functions that can be called from elsewhere in the calculator, such as Home view, CAS view, the Spreadsheet app, and in a program (see "App menu" on page 312)

  Note that the Geometry app functions can be called from elsewhere in the calculator, but they are not available from the App menu. For that reason, the Geometry functions are not described in this chapter, They are described in the Geometry chapter.

- **User**

  The functions that you have created (see "Creating your own functions" on page 371) and the programs you have created that contain global

- **Catlg**

  All the functions and commands:

  – on the **Math** menu

  – on the **CAS** menu

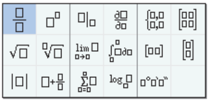
  – used in the Geometry app

  – used in programming

- used in the Matrix Editor
- used in the List Editor
- and some additional functions and commands

See “Ctlg menu” on page 338.

Some functions can be chosen from the math template (displayed by pressing). See “Math template” on page 21.



You can also create your own functions. See “Creating your own functions” on page 371.

Setting the form of menu items

You can choose to have entries on the Math and CAS menus presented either by their descriptive name or their command name. (The entries on the Catlg menu are always presented by their command name.)

Descriptive name	**Command name**
Factors List	ifactors
Complex Zeros	cZeros
Groebner Basis	gbasis
Factor by Degree	factor_xn
Find Roots	proot

The default menu presentation mode is to provide the descriptive names for the Math and CAS functions. If you prefer the functions to be presented by their command name, deselect the **Menu Display** option on the second page of the **Home Settings** screen (see “Home settings” on page 27).

Abbreviations used in this chapter

In describing the syntax of functions and commands, the following abbreviations are used:

`Expr`: a mathematical expression

`Poly`: a polynomial

`LstPoly`: a list of polynomials

`Frac`: a fraction

RatFrac: a rational fraction

Fnc: a function

Var: a variable

LstVar: a list of variables

Keyboard functions

The most frequently used functions are available directly from the keyboard. Many of the keyboard functions also accept complex numbers as arguments. Enter the keys and inputs shown below and press Enter to evaluate the expression.

In the examples below, shifted functions are represented by the actual keys to be pressed, with the function name shown in parentheses. For example, Shift SIN (ASIN) means that to make an arc sine calculation (ASIN), you press Shift SIN.

The examples below show the results you would get in Home view. If you are in the CAS, the results are given in simplified symbolic format. For example:

Shift x^2 320 returns 17.88854382 in Home view, and 8*√5 in the CAS.

+, −, ×, ÷

Add, subtract, multiply, divide. Also accepts complex numbers, lists, and matrices.

value1 + *value2*, etc.

LN

Natural logarithm. Also accepts complex numbers.

LN(*value*)

Example:

LN(1) returns 0

Shift LN (e^x)

Natural exponential. Also accepts complex numbers.

Shift LN *value*

Example:

Shift LN 5 returns 148.413159103

[LOG]

Common logarithm. Also accepts complex numbers.

[LOG](*value*)

Example:

[LOG]`(100)` returns `2`

[Shift] [LOG] (10^x)

Common exponential (antilogarithm). Also accepts complex numbers.

[Shift] [LOG] *value*

Example:

[Shift] [LOG] `3` returns `1000`

[SIN] [COS] [TAN]

Sine, cosine, tangent. Inputs and outputs depend on the current angle format: degrees or radians.

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

Example:

`TAN(45)` returns `1` (degrees mode)

[Shift] [SIN] (ASIN)

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

`ASIN`(*value*)

Example:

`ASIN(1)` returns `90` (degrees mode)

[Shift] [COS] (ACOS)

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

`ACOS`(*value*)

Example:

`ACOS(1)` returns `0` (degrees mode)

[Shift] [TAN] (ATAN)

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

`ATAN`(*value*)

Example:

`ATAN(1)` returns `45` (degrees mode)

[x^2] — Square. Also accepts complex numbers.

value [x^2]

Example:

`18`[x^2] returns `324`

[Shift] [x^2] — Square root. Also accepts complex numbers.

[Shift] [x^2] *value*

Example:

[Shift] [x^2] 320 returns `17.88854382`

[x^y] — *x* raised to the power of *y*. Also accepts complex numbers.

value [x^y] *power*

Example:

`2` [x^y] `8` returns `256`

[Shift] [x^y] — The *n*th root of *x*.

root [x^y] *value*

Example:

`3` [x^y] `8` returns `2`

[Shift] [÷] — Reciprocal.

value [Shift] [÷]

Example:

`3` [Shift] [÷] returns `.333333333333`

[+/−] — Negation. Also accepts complex numbers.

[+/−] *value*

Example:

[+/−] `(1+2*i)` returns `-1-2*i`

[Shift] [+/−] `(|x|)` — Absolute value.

Shift +/- (*value*)
Shift +/- ((*x*+*y***i*))
Shift +/- (matrix)

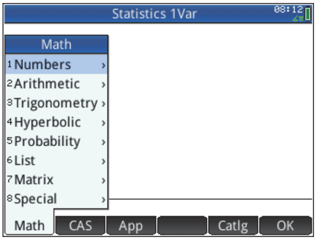
For a complex number, `ABS`((*x*+*y***i*)) returns $\sqrt{x^2+y^2}$. For a matrix, `ABS` returns the Frobenius norm of the matrix.

Example:

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

Math menu

Press Toolbox to open the Toolbox menus (one of which is the Math menu). The functions and commands available on the Math menu are listed as they are categorized on the menu.



Numbers

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

`CEILING(value)`

Examples:

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

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

`FLOOR(value)`

Example:

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

IP Integer part.

`IP(value)`

Example:

`IP(23.2)` returns `23`

FP Fractional part.

`FP(value)`

Example:

`FP (23.2)` returns `.2`

Round Rounds *value* to decimal *places*. Also accepts complex numbers.

`ROUND(value,places)`

`ROUND` can also round to a number of significant digits if *places* is a negative integer (as shown in the second example below).

Examples:

`ROUND(7.8676,2)` returns `7.87`
`ROUND(0.0036757,-3)` returns `0.00368`

Truncate Truncates *value* to decimal *places*. Also accepts complex numbers.

`TRUNCATE(value,places)`

Example:

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

Mantissa Mantissa—that is, the significant digits—of *value*, where value is a floating-point number.

`MANT(value)`

Example:

`MANT(21.2E34)` returns `2.12`

Exponent Exponent of *value*. That is, the integer component of the power of 10 that generates *value*.

`XPON(value)`

Example:

`XPON(123456)` returns `5` (since $10^{5.0915...}$ equals 123456)

Arithmetic

Maximum Maximum. The greater of two values.

`MAX(value1,value2)`

Example:

MAX(8/3,11/4) returns 2.75

Note that in Home view a non-integer result is given as a decimal fraction. If you want to see the result as a vulgar fraction, press CAS Settings. This opens the computer algebra system. If you want to return to Home view to make further calculations, press Settings.

Minimum Minimum. The lesser of two values.

MIN(value1,value2)

Example:

MIN(210,25) returns 25

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

value1 MOD value2

Example:

74 MOD 5 returns 4

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

FNROOT(expression,variable,guess)

Example:

FNROOT((A*9.8/600)-1,A,1) returns 61.224489796.

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

%(x,y)

Example:

%(20,50) returns 10

Complex

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

ARG(x+y*i)

Example:

ARG(3+3*i) returns 45 (degrees mode)

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

```
CONJ(x+y*i)
```

Example:

`CONJ(3+4*i)` returns `(3-4*i)`

Real Part Real part x, of a complex number, $(x+y*i)$.

```
RE(x+y*i)
```

Example:

`RE(3+4*i)` returns `3`

Imaginary Part Imaginary part, *y*, of a complex number, $(x+y*i)$.

```
IM(x+y*i)
```

Example:

`IM(3+4*i)` returns `4`

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

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

Examples:

`SIGN(POLYEVAL[1,2,-25,-26,2],-2)` returns `-1`
`SIGN((3,4))` returns `(.6,.8)`

Exponential

ALOG Antilogarithm (exponential).

```
ALOG(value)
```

EXPM1 Exponent minus 1: $e^x - 1$.

```
EXPM1(value)
```

LNP1 Natural log plus 1: $\ln(x+1)$.

```
LNP1(value)
```

Trigonometry

The trigonometry functions can also take complex numbers as arguments. For SIN, COS, TAN, ASIN, ACOS, and ATAN, see “Keyboard functions” on page 285.

CSC Cosecant: 1/sin*x*.

```
CSC(value)
```

ACSC Arc cosecant.

```
ACSC(value)
```

SEC Secant: 1/cos*x*.

```
SEC(value)
```

ASEC Arc secant.

```
ASEC(value)
```

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

```
COT(value)
```

ACOT Arc cotangent.

```
ACOT(value)
```

Hyperbolic

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

SINH Hyperbolic sine.

```
SINH(value)
```

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

```
ASINH(value)
```

COSH Hyperbolic cosine

```
COSH(value)
```

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

```
ACOSH(value)
```

TANH Hyperbolic tangent.

```
TANH(value)
```

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

```
ATANH(value)
```

Probability

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

```
value!
```

Example:

`5!` returns `120`

Combination The number of combinations (without regard to order) of *n* things taken *r* at a time.

`COMB(n,r)`

Example: Suppose you want to know how many ways five things can be combined two at a time.

`COMB(5,2)` returns `10.`

Permutation Number of permutations (with regard to order) of *n* things taken *r* at a time.

`PERM (n,r)`

Example: Suppose you want to know how many permutations there are for five things taken two at a time.

`PERM(5,2)` returns `20.`

Random

Number Random number. With no argument, this function returns a random number between zero and one. With one integer argument *a*, it returns a random number between 0 and *a*. With three integer arguments, *n*, *a*, and *b*, returns *n* random number between *a* and *b*.

`RANDOM`

`RANDOM(a)`

`RANDOM(n,a,b)`

Integer Random integer. With one integer argument *a*, it returns a random integer between 0 and *a*. With three integer arguments, *n*, *a*, and *b*, returns *n* random integers between *a* and *b*.

`RANDINT(a)`

`RANDINT(n,a,b)`

Normal Random real number with normal distribution N(μ,σ).

`RANDNORM(μ,σ)`

Seed Sets the seed value on which RAND() operates. By specifying the same seed value on two or more calculators, you ensure that the same random numbers appear on each calculator when RAND() is executed.

`RANDSEED(value)`

Density

Normal Normal probability density function. Computes the probability density at value *x*, given the mean, μ, and standard deviation, σ, of a normal distribution. If only one argument is supplied, it is taken as *x*, and the assumption is that μ=0 and σ=1.

```
NORMALD([μ,σ,]x)
```

Example:

`NORMALD(0.5)` and `NORMALD(0,1,0.5)` both return `0.352065326764.`

T Student's t probability density function. Computes the probability density of the Student's t-distribution at *x*, given *n* degrees of freedom.

```
STUDENT(n,x)
```

Example:

`student(3,5.2)` returns `0.00366574413491.`

χ^2 χ^2 probability density function. Computes the probability density of the χ^2 distribution at *x*, given *n* degrees of freedom.

```
CHISQUARE(n,x)
```

Example:

`CHISQUARE(2,3.2)` returns `0.100948258997.`

F Fisher (or Fisher–Snedecor) probability density function. Computes the probability density at the value *x*, given numerator *n* and denominator *d* degrees of freedom.

```
FISHER(n,d,x)
```

Example:

`FISHER(5,5,2)` returns `0.158080231095.`

Binomial Binomial probability density function. Computes the probability of *k* successes out of *n* trials, each with a probability of success of *p*. Returns Comb(n,k) if there is no third argument. Note that *n* and *k* are integers with $k \le n$.

```
BINOMIAL(n,k,p)
```

Example: Suppose you want to know the probability that just 6 heads would appear during 20 tosses of a fair coin.

`BINOMIAL(20,6,0.5)` returns `0.03696441652002.`

Poisson Poisson probability mass function. Computes the probability of *k* occurrences of an event during a future interval given μ, the mean of the occurrences of that event during that interval in the past. For this function, *k* is a non-negative integer and μ is a real number.

```
POISSON(m,k)
```

Example: Suppose that on average you get 20 emails a day. What is the probability that tomorrow you will get 15?

`POISSON(20,15)` returns `0.0516488535318.`

Cumulative

Normal Cumulative normal distribution function. Returns the lower-tail probability of the normal probability density function for the value *x*, given the mean, μ, and standard deviation, σ, of a normal distribution. If only one argument is supplied, it is taken as *x*, and the assumption is that μ=0 and σ=1.

```
NORMAL_CDF(μ,σ,]x)
```

Example:

`NORMAL_CDF(0,1,2)` returns `0.97724986805.`

T Cumulative student's t distribution function. Returns the lower-tail probability of the student's t-probability density function at *x*, given *n* degrees of freedom.

```
STUDENT_CDF(n,x)
```

Example:

`student_cdf(3,-3.2)` returns `0.0246659214814.`

χ^2 Cumulative χ^2 distribution function. Returns the lower-tail probability of the χ^2 probability density function for the value *x*, given *n* degrees of freedom.

```
CHISQUARE_CDF(n,k)
```

Example:

`CHISQUARE_CDF(2,6.1)` returns `0.952641075609.`

F Cumulative Fisher distribution function. Returns the lower-tail probability of the Fisher probability density function for the value *x*, given numerator *n* and denominator *d* degrees of freedom.

```
FISHER_CDF(n,d,x)
```

Example:

FISHER_CDF(5,5,2) returns 0.76748868087.

Binomial Cumulative binomial distribution function. Returns the probability of *k* or fewer successes out of *n* trials, with a probability of success, *p* for each trial. Note that *n* and *k* are integers with $k \le n$.

BINOMIAL_CDF(n,p,k)

Example: Suppose you want to know the probability that during 20 tosses of a fair coin you will get either 0, 1, 2, 3, 4, 5, or 6 heads.

BINOMIAL_CDF(20,0.5,6) returns 0.05765914517.

Poisson Cumulative Poisson distribution function. Returns the probability *x* or fewer occurrences of an event in a given time interval, given μ expected occurrences.

POISSON_CDF(μ,*x*)

Example:

POISSON_CDF(4,2) returns 0.238103305554.

Inverse

Normal Inverse cumulative normal distribution function. Returns the cumulative normal distribution value associated with the lower-tail probability, *p*, given the mean, μ, and standard deviation, σ, of a normal distribution. If only one argument is supplied, it is taken as *p*, and the assumption is that μ=0 and σ=1.

NORMAL_ICDF([μ,σ,]p)

Example:

NORMAL_ICDF(0,1,0.841344746069) returns 1.

T Inverse cumulative student's t distribution function. Returns the value *x* such that the student's-t lower-tail probability of *x*, with *n* degrees of freedom, is *p*.

STUDENT_ICDF(n,p)

Example:

STUDENT_ICDF(3,0.0246659214814) returns –3.2.

χ^2 Inverse cumulative χ^2 distribution function. Returns the value *x* such that the χ^2 lower-tail probability of *x*, with *n* degrees of freedom, is *p*.

`CHISQUARE_ICDF(n,p)`

Example:

`CHISQUARE_ICDF(2,0.952641075609)` returns `6.1`.

F Inverse cumulative Fisher distribution function. Returns the value *x* such that the Fisher lower-tail probability of *x*, with numerator *n* and denominator *d* degrees of freedom, is *p*.

`FISHER_ICDF(n,d,p)`

Example:

`FISHER_ICDF(5,5,0.76748868087)` returns `2`.

Binomial Inverse cumulative binomial distribution function. Returns the number of successes, *k,* out of *n* trials, each with a probability of *p,* such that the probability of *k* or fewer successes is *q*.

`BINOMIAL_ICDF(n,p,q)`

Example:

`BINOMIAL_ICDF(20,0.5,0.6)` returns `11`.

Poisson Inverse cumulative Poisson distribution function. Returns the value *x* such that the probability of *x* or fewer occurrences of an event, with μ expected (or mean) occurrences of the event in the interval, is *p*.

`POISSON_ICDF(μ,p)`

Example:

`POISSON_ICDF(4,0.238103305554)` returns `3`.

List

These functions work on data in a list. They are explained in detail in chapter 23, “Lists”, beginning on page 399.

Matrix

These functions work on matrix data stored in matrix . They are explained in detail in chapter 24, “Matrices”, beginning on page 411.

Special

Beta Returns the value of the beta function (B) for two reals *a* and *b*.

`Beta(a,b)`

Gamma Returns the value of the gamma function (Γ) for a number *a*.

```
Gamma(a)
```

Psi Returns the value of the *n*th derivative of the digamma function at *x*=*a*, where the digamma function is the first derivative of $\ln(\Gamma(x))$.

```
Psi(a,n)
```

Zeta Returns the value of the zeta function (Z) for a real *x*.

```
Zeta(x)
```

erf Returns the floating point value of the error function at *x*=*a*.

```
erf(a)
```

erfc Returns the value of the complementary error function at *x*=*a*.

```
erfc(a)
```

Ei Returns the exponential integral of an expression.

```
Ei(Expr)
```

Si Returns the sine integral of an expression.

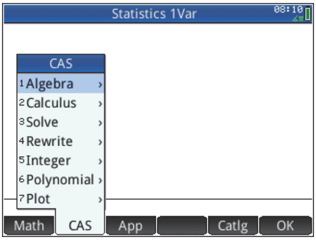
```
Si(Expr)
```

Ci Returns the cosine integral of an expression.

```
Ci(Expr)
```

CAS menu

Press [Toolbox] to open the Toolbox menus (one of which is the CAS menu). The functions on the CAS menu are those most commonly used. Many more functions are available. See "Ctlg menu", beginning on page 338.



Note that the Geometry functions appear on the CAS menu when the Geometry app is currently active or was the last-used app. They are described in "Geometry functions and commands", beginning on page 151.

Algebra

Simplify Returns an expression simplified.

```
simplify(Expr)
```

Collect Returns a polynomial or list of polynomials factorized over the field of the coefficients.

```
collect(Poly or LstPoly)
```

Expand Returns an expression expanded.

```
expand(Expr)
```

Factor Returns a polynomial factorized.

```
factor(Poly)
```

Substitute Returns the solution when a value is substituted for a variable in an expression.

```
subst(Expr,Var(v)=value(a))
```

Partial Fraction Returns the partial fraction expansion of a rational fraction.

```
partfrac(RatFrac)
```

Extract

Numerator Returns the numerator of a fraction (after simplifying the fraction if necessary).

```
numer(Frac(a/b) or RatFrac)
```

Denominator Returns the denominator of a fraction (after simplifying the fraction if necessary).

```
denom(Frac(a/b) or RatFrac)
```

Left Side Returns the left side of an equation or the left bound of an interval.

```
lhs(Equal(a=b) or Interval(a...b))
```

Right Side Returns the right side of an equation or the left bound of an interval.

```
rhs(Equal(a=b) or Interval(a...b))
```

Calculus

Differentiate With one expression as argument, returns derivative of the expression with respect to x. With one expression and one variable as arguments, returns the derivative or partial derivative of the expression with respect to the variable. With one expression and more than one variable as arguments, returns the derivative of the expression with respect to the derivation in the second argument onwards. in the arguments can be followed by $*k* (*k* is an integer) to indicate the number of times the expression should be derived with respect to the variable. For example, diff(exp(x*y),x$3,y$2,z) is the same as diff(exp(x*y),x,x,x,y,y,z).

```
diff(Expr,[var])
```

or

```
diff(Expr,var1$k1,var2$k2,...)
```

Integrate Returns the indefinite integral of an expression. With one expression as argument, returns the indefinite integral with respect to *x*. With the optional second, third and fourth arguments you can specify the variable of integration and the bounds of the integrate.

```
int(Expr,[Var(x)],[Real(a)],[Real(b)])
```

Limit Returns the limit of an expression when the variable approaches a limit point *a* or +/– infinity. With the optional fourth argument you can specify whether it is the limit from below, above or bidirectional (*d*=–1 for limit from below and *d*=+1 for limit from above, *d*=0 for bidirectional limit). If the fourth argument is not provided, the limit returned is bidirectional.

```
limit(Expr,Var,Val(a),[Dir(d)])
```

Series Returns the series expansion of an expression in the vicinity of a given equality variable. With the optional third and fourth arguments you can specify the order and direction of the series expansion. If no order is specified the series returned is fifth order. If no direction is specified, the series is bidirectional.

```
series(Expr,Equal(var=limit_point),[Orde
r],[Dir(1,0,-1)])
```

Summation With two arguments, returns the discrete antiderivative of the expression with respect to the variable.

```
sum(Expr,Var)
```

With four arguments, returns the discrete sum of the expression with respect to the variable from *a* to *b.*

```
sum(Expr,Var,VarMin(a),VarMax(b))
```

Differential

Curl Returns the rotational curl of a vector field, defined by:

curl([A,B,C],[x,y,z])=[dC/dy-dB/dz,dA/dz-dC/dx,dB/dx-dA/dy].

```
curl(Lst(A,B,C),Lst(x,y,z))
```

Divergence Returns the divergence of a vector field, defined by:

divergence([A,B,C],[x,y,z])=dA/dx+dB/dy+dC/dz.

```
divergence(Lst(A,B,C),Lst(x,y,z))
```

Gradient Returns the gradient of an expression. With a list of as second argument, returns the vector of partial derivatives for all .

```
grad(Expr,LstVar)
```

Hessian Returns the Hessian matrix of an expression.

```
hessian(Expr,LstVar)
```

Integral

By Parts v(x) Performs integration by parts of the expression f(*x*)=u(*x*)*v'(*x*) with f(*x*) as the first argument and v(*x*) (or 0) as the second argument. With the optional third, fourth and fifth arguments you can specify a variable of integration and bounds of the integrate. If no variable of integration is provided, it is taken as *x*.

```
ibpdv(Expr(f(x)),Expr(v(x)),[Var(x)],[Re
al(a)],[Real(b)])
```

By Parts u(v) Performs integration by parts of the expression f(*x*)=u(*x*)*v'(*x*) with f(*x*) as the first argument and u(*x*) (or 0) as the second argument. With the optional third, fourth and fifth arguments you can specify a variable of integration and bounds of the integrate. If no variable of integration is provided, it is taken as *x*.

```
ibpu(Expr(f(x)),Expr(u(x)),[Var(x)],[Rea
l(a)],[Real(b)])
```

F(b)–F(a) Returns F(*b*)–F(*a*).

```
preval(Expr(F(var)),Real(a),Real(b),[Var
])
```

Limits

Riemann Sum Returns in the neighbourhood of $n=+\infty$ an equivalent of the sum of Xpr(var1,var2) for var2 from var2=1 to var2=var1 when the sum is looked at as a Riemann sum associated with a continuous function defined on [0,1].

```
sum_riemann(Expr(Xpr),Lst(var1,var2))
```

Taylor Returns the Taylor series expansion of an expression. With the optional second and third arguments you can specify the limit point and the order of the expansion. If no limit point is provided, it is taken as x=0. If no order is provided, the series returned is fifth order.

```
taylor(Expr,[Var=limit_point],[Order])
```

Taylor of Quotient Returns the quotient Q of the division of polynomial A by polynomial B by increasing power order, with degree(Q)≤ n or Q=0. In other words, Q is the Taylor expansion at order n of A/B in the vicinity of x=0.

```
divpc(A,B,Intg(n))
```

Transform

Laplace Returns the Laplace transform of an expression.

```
laplace(Expr,[Var],[LapVar])
```

Inverse Laplace Returns the inverse Laplace transform of an expression.

```
invlaplace(Expr,[Var],[IlapVar])
```

FFT With one argument, returns the discrete Fourier transform in R.

```
fft(Vect)
```

With three arguments, returns the discrete Fourier transform in the field Z/pZ, with *a* as primitive *n*th root of 1 (n=size(L)).

```
fft((Vect(L),Intg(a),Intg(p))
```

Inverse FFT Returns the inverse discrete Fourier transform.

```
ifft(Vect)
```

Solve

Solve Returns the solutions to a polynomial equation or a set of polynomial equations.

```
solve(Expr,[Var])
```

Zeros With an expression as argument, returns the zeros (real or complex according to the mode) of the expression. With a list of expressions as argument, returns the matrix where the lines are the solutions of the system (i.e. expression1=0, expression2=0,...,).

```
zeros(Expr,[Var])
```

or

```
zeros([LstExpr],[LStVar])
```

Complex Solve Returns a list where the elements are complex solutions of the system of polynomial equations.

```
csolve(LstEq,LstVar)
```

Complex Zeros With an expression as argument, returns the complex zeros of the expression. With a list of expressions as argument, returns the matrix where the lines are the solutions of the system (i.e. expression1=0, expression2=0,...,).

```
Czeros(Expr,[Var])
```

or

```
Czeros([LstExpr],[LStVar])
```

Numerical Solve Returns the numerical solution of an equation or a system of equations. With the optional third argument you can specify a guess for the solution or an interval within which it is expected that the solution will occur. With the optional fourth argument you can name the iterative algorithm to be used by the solver.

```
nSolve(Expr,Var,[Guess or
Interval],[Method])
```

Differential Equation Returns the solution to a differential equation.

```
deSolve(Eq,[TimeVar],FncVar)
```

ODE Solve Returns an approximate value of *y* at a final value (*t1*) of a given variable, where *y(t)* is the solution of: y'(t)=f(t,y(t)), y(t0)=y0.

```
odesolve(Expr(f(t,y)),VectVar([t,y]),Vec
tInitCond([t0,y0]),FinalVal(t1),[tstep=V
al,curve])
```

Linear System Returns the solution to a system of linear equations.

```
linsolve(LstLinEq,LstVar)
```

Rewrite

lncollect Returns an expression rewritten with the logarithms collected. (applies ln(*a*)+*n**ln(*b*)->ln(*a***b*^*n*) for integers *n*).

```
lncollect(Expr)
```

powexpand Returns an expression with a power of sum rewritten as a product of powers.

```
powexpand(Expr)
```

tExpand Returns a transcendental expression in expanded form.

```
tExpand(Expr)
```

Exp & Ln

ey*lnx Returns an expression of the form exp(*n**ln(*x*)) rewritten as a power of *x*.

```
exp2pow(Expr)
```

y*lnx Returns an expression with powers rewritten as an exponentials.

```
pow2exp(Expr)
```

exp2trig Returns an expression with complex exponentials rewritten in terms of sin and cos.

```
exp2trig(Expr)
```

expexpand Returns an expression with exponentials in expanded form.

```
expexpand(Expr)
```

Sine

asinx → acosx Returns an expression with arcsin(*x*) rewritten as pi/2-arccos(*x*).

```
asin2acos(Expr)
```

asinx → atanx Returns an expression with arcsin(*x*) rewritten as arctan(*x*/sqrt(1-*x*^2)).

```
asin2atan(Expr)
```

sinx → cosx/tanx Returns an expression with sin(*x*) rewritten as cos(*x*)*tan(*x*).

```
sin2costan(Expr)
```

Cosine

acosx → asinx Returns an expression with arccos(*x*) rewritten as pi/2-arcsin(*x*).

```
acos2asin(Expr)
```

acosx → atanx Returns an expression with arccos(*x*) rewritten as pi/2-arctan(*x*/sqrt(1-*x*^2)).

```
acos2atan(Expr)
```

cosx → sinx/tanx Returns an expression with cos(*x*) rewritten as sin(*x*)/tan(*x*).

```
cos2sintan(Expr)
```

Tangent

atanx → asinx Returns an expression with arctan(*x*) rewritten as arcsin(*x*/sqrt(1+*x*^2)).

```
atan2asin(Expr)
```

atanx → acosx Returns an expression with arctan(*x*) rewritten as pi/2-arccos(*x*/sqrt(1+*x*^2)).

```
atan2acos(Expr)
```

tanx → sinx/cosx Returns an expression with tan(*x*) rewritten as sin(*x*)/cos(*x*).

```
tan2sincos(Expr)
```

halftan Returns an expression with sin(*x*), cos(*x*) or tan(*x*) rewritten as tan(*x*/2).

```
halftan(Expr)
```

Trig

trigx → sinx Returns an expression simplified using the formulas sin(*x*)^2+cos(*x*)^2=1 and tan(*x*)=sin(*x*)/cos(*x*) (privileging sine).

```
trigsin(Expr)
```

trigx → cosx Returns an expression simplified using the formulas sin(*x*)^2+cos(*x*)^2=1 and tan(*x*)=sin(*x*)/cos(*x*) (privileging cosine).

```
trigcos(Expr)
```

trigx → tanx Returns an expression simplified using the formulas sin(*x*)^2+cos(*x*)^2=1 and tan(*x*)=sin(*x*)/cos(*x*) (privileging tangent).

```
trigtan(Expr)
```

atrig2ln Returns an expression with inverse trigonometric functions rewritten as logarithmic functions.

```
atrig2ln(Expr)
```

tlin Returns a trigonometric expression with the products and integer powers linearized.

```
tlin(ExprTrig)
```

tCollect Returns a trigonometric expression linearized and with any sine and cosine of the same angle put together.

```
tCollect(Expr)
```

trigexpand Returns a trigonometric expression in expanded form.

```
trigexpand(Expr)
```

trig2exp Returns an expression with trigonometric functions rewritten as complex exponentials (without linearization).

```
trig2exp(Expr)
```

Integer

Divisors Returns the list of divisors of an integer or a list of integers.

```
idivis(Intg(a) or (LstIntg))
```

Factors Returns an integer decomposed into its prime factors.

```
ifactor(Intg(a))
```

Factor List Returns the list of prime factors of an integer or a list of integers. Each factor is followed by its multiplicity.

```
ifactors(Intg(a) or (LstIntg))
```

GCD Returns the greatest common divisor of two integers.

```
gcd((Intg(a),Intg(b))
```

LCM Returns the lowest common multiple of two integers.

```
lcm((Intg(a),Intg(b))
```

Prime

Test if Prime Tests whether or not a given integer is a prime number.

```
isprime(Intg(a))
```

Nth Prime Returns the *n*th prime number less than 10000.

```
ithprime(Intg(n))
```

Next Prime Returns the next prime or pseudo-prime after an integer.

```
nextprime(Intg(a))
```

Previous Prime Returns the prime or pseudo-prime number closest to but smaller than an integer.

```
prevprime(Intg(a))
```

Euler Compute’s Euler's totient for an integer.

```
euler(Intg(n))
```

Division

Quotient Returns the integer quotient of the Euclidean division of two integers.

```
iquo(Intg(a),Intg(b))
```

Remainder Returns the integer remainder from the Euclidean division of two integers.

```
irem(Intg(a),Intg(b))
```

a^n MOD p Returns a^n modulo p in $[0;p-1]$.

```
powmod(Intg(a),Intg(n),Intg(p),[Expr(P(x
))],[Var])
```

Chinese Remainder Returns the Chinese remainder of two lists of integers.

```
ichinrem(LstIntg(a,p),LstIntg(b,q))
```

Polynomial

Find Roots Returns all computed roots of a polynomial given by its coefficients. (It may not work if roots are not simple.)

```
proot(Vect||Poly)
```

Coefficients With an integer as third argument, returns the coefficient of a polynomial of degree given in the third argument. With no third argument, returns the list of coefficients of the polynomial.

```
coeff(Expr,[Var],degree)
```

Divisors Returns the list of divisors of a polynomial or a list of polynomials.

```
divis(Poly or LstPoly)
```

Factor List Returns the list of prime factors of a polynomial or a list of polynomials. Each factor is followed by its multiplicity.

```
factors(Poly or LstPoly)
```

GCD Returns the greatest common divisor of two polynomials of several .

```
gcd(Poly,Poly)
```

LCM Returns the lowest common multiple of two polynomials of several .

```
lcm(Poly,Poly))
```

Create

Poly to Coef With a variable as second argument, returns the coefficients of a polynomial with respect to the variable. With a list of as second argument, returns the internal format of the polynomial.

```
symb2poly(Expr,[Var])
```

or

```
symb2poly(Expr,ListVar)
```

Coef to Poly With one list as argument, returns a polynomial in *x* with coefficients (in decreasing order) obtained from the list. With a variable as second argument, returns a polynomial in the variable as for one argument but the polynomial is in the variable specified in the second argument.

```
poly2symb(Lst,Var)
```

Roots to Coef Returns the coefficients (in decreasing order) of the univariate polynomial of roots specified in the argument.

```
pcoef(Vect)
```

Roots to Poly Returns the rational function that has the roots and poles specified in the argument.

```
fcoeff(Lst(root||pole,order))
```

Random Returns a polynomial of variable specified in the first argument, of degree *n* and where the coefficients are random integers in the range –99 through 99 with uniform distribution or according to the law specified in the third argument.

```
randPoly([Var(var)],Intg(n),[law])
```

Minimum With only a matrix as argument, returns the minimal polynomial in *x* of a matrix written as a list of its coefficients. With a matrix and a variable as arguments, returns the minimum polynomial of the matrix written in symbolic form with respect to the variable.

```
pmin(Mtrx,[Var])
```

Algebra

Quotient Returns the Euclidean quotient of two polynomials written as vectors or in symbolic form.

```
quo((Vect),(Vect),[Var])
```

or

```
quo((Poly),(Poly),[Var])
```

Remainder Returns the Euclidean remainder of two polynomials written as vectors or in symbolic form.

```
rem((Vect),(Vect),[Var])
```

or

```
rem((Poly),(Poly),[Var])
```

Degree Returns the degree of a polynomial.

```
degree(Poly)
```

Factor by Degree Returns a polynomial factorized in *x*^*n*, where *n* is the degree of polynomial.

```
factor_xn(Poly)
```

Coef. of GCD Returns the greatest common divisor (GCD) of the coefficients of a polynomial.

```
content(Poly(P),[Var])
```

Zero Count With a polynomial and a variable as arguments, returns the list of the Sturm sequences and multiplicities of the square-free factors of the polynomial with respect to the variable. With a polynomial, a variable and two reals as arguments, returns the number of sign changes of the polynomial over the interval specified by the two reals.

```
sturmseq(Poly,[Var])
```

or

```
sturmseq(Poly,[Var],a,b)
```

Chinese Remainder Returns the Chinese remainder of the polynomials written as lists of coefficients or in symbolic form.

```
chinrem([Lst||Expr,Lst||Expr],[Lst||Expr
,Lst||Expr])
```

Special

Cyclotomic Returns the list of coefficients of the cyclotomic polynomial of an integer.

```
cyclotomic(Int)
```

Groebner Basis Returns the Groebner basis of the ideal spanned by a list of polynomials.

```
gbasis(LstPoly,LstVar)
```

Groebner Remainder Returns the remainder of the division of a polynomial by the Groebner basis of a list of polynomials.

```
greduce(Poly,LstPoly,LstVar)
```

Hermite Returns the Hermite polynomial of degree *n.*

```
hermite(Intg(n))
```

Lagrange Returns the Lagrange polynomial for two lists. The list in the first argument corresponds to the abscissa values, and the list in the second argument corresponds to the ordinate values.

```
lagrange((Lst_xk,Lst_yk)
```

or

```
lagrange(Mtrx_2*n)
```

Laguerre Returns the Laguerre polynomial of degree *n.*

```
laguerre(Intg(n))
```

Legendre Returns the Legendre polynomial of degree *n.*

```
legendre(Intg(n))
```

Chebyshev Tn Returns the Tchebyshev polynomial of first kind of degree *n.*

```
tchebyshev1(Intg(n))
```

Chebyshev Un Returns the Tchebyshev polynomial of second kind of degree *n.*

```
tchebyshev2(Intg(n))
```

Plot

Function Plots the graph of an expression of one or two with superposition.

```
plotfunc(Expr,[Var(x)],[Intg(color)])
```

or

```
plotfunc(Expr,[VectVar],[Intg(color)])
```

Implicit Plots the graph of the implicit equation f(Var1,Var2)=0.

```
plotimplicit(Expr,Var1,Var2)
```

Density Plots the graph of the function z=f(*x*,*y*) in the plane where the values of *z* are represented by different colors.

```
plotdensity(Expr,[x=xrange,y=yrange],[z]
,[xstep],[ystep])
```

Slopefield Draws the tangent of the differential equation y'=f(*t*,*y*), where the first argument is the expression f(*t*,*y*) (*y* is the real variable and *t* is the abscissa), the second argument is the vector of (abscissa must be listed first), and the third argument is the optional range.

```
plotfield(Expr,VectVar,[Opt])
```

Contour Draws eleven contour lines of the surface defined by the expression z=f(*x*,*y*) for z=–10,–8,...,8,10. With a list of values as third argument, contour lines will be drawn instead for the z values given in the list.

```
plotcontour(Expr(Xpr),[LstVar],[LstVal])
```

ODE Draws the solution of the differential equation y'=f(*t*,*y*) that crosses the point (t0,y0), where the first argument is the expression f(*t*,*y*), the second argument is the vector of (abscissa must be listed first), and the third argument is (t0,y0).

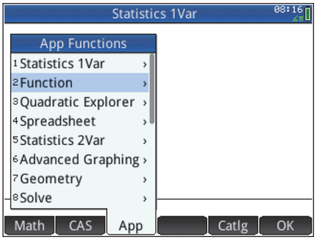
```
plotode(Expr,VectVar,VectInitCond)
```

List Draws the polygonal line through the points of abscissa 0,...,*n* and ordinate l=[y0,...,yn], or draws the line through the points of abscissa (the first column in the matrix) and ordinate (the second column in the matrix).

```
plotlist(Lst(l)||Mtrx(M))
```

App menu

Press to open the Toolbox menus (one of which is the App menu). App functions are used in HP apps to perform common calculations. For example, in the Function app, the Plot view **Fcn** menu has a function called `SLOPE` that calculates the slope of a given function at a given point. The `SLOPE` function can also be used from the Home view or a program to give the same results The App functions described in this section are grouped by app.



Function app functions

The Function app functions provide the same functionality found in the Function app's Plot view under the FCN menu. All these operations work on functions. The functions may be expressions in X or the names of the Function app variable F0 through F9.

AREA

Area under a curve or between curves. Finds the signed area under a function or between two functions. Finds the area under the function Fn or below Fn and above the function Fm, from lower X-value to upper X-value.

`AREA(Fn,[Fm,]lower,upper)`

Example:

`AREA(-X,X`^{2}`-2,-2,1)` returns `4.5`

EXTREMUM

Extremum of a function. Finds the extremum (if one exists) of the function Fn that is closest to the X-value guess.

`EXTREMUM(Fn, guess)`

Example:

`EXTREMUM(X`^{2}`-X-2,0)` returns `0.5`

ISECT

Intersection of two functions. Finds the intersection (if one exists) of the two functions Fn and Fm that is closest to the X-value guess.

`ISECT(Fn,Fm,guess)`

Example:

`ISECT(X,3-X,2)` returns `1.5`

ROOT Root of a function. Finds the root of the function Fn (if one exists) that is closest to the X-value guess.

`ROOT(Fn,guess)`

Example:

`ROOT(3-X²,2)` returns `1.732...`

SLOPE Slope of a function. Returns the slope of the function Fn at the X-value (if value exists).

`SLOPE(Fn,value)`

Example:

`SLOPE(3-X²,2)` returns `-4`

Solve app functions

The Solve app has a single function that solves a given equation or expression for one of its . *En* may be an equation or expression, or it may be the name of one of the Solve Symbolic E0-E9.

SOLVE Solve. Solves an equation for one of its . Solves the equation *En* for the variable *var*, using the value of *guess* as the initial value for the value of the variable *var*. If *En* is an expression, then the value of the variable *var* that makes the expression equal to zero is returned.

`SOLVE(En,var,guess)`

Example:

`SOLVE(X²-X-2,X,3)` returns `2`

This function also returns an integer that is indicative of the type of solution found, as follows:

`0`—an exact solution was found

`1`—an approximate solution was found

`2`—an extremum was found that is as close to a solution as possible

3—neither a solution, an approximation, nor an extremum was found

See chapter 12, “Solve app”, beginning on page 235, for more information about the types of solutions returned by this function.

Spreadsheet functions

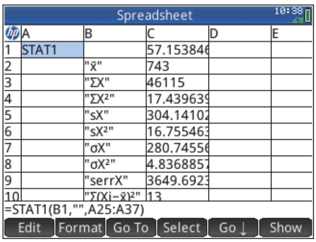
The spreadsheet functions can be selected from the App Toolbox menu (> App > `Spreadsheet`). They can also be selected from the View menu (View Copy) when the Spreadsheet app is open.

The typical syntax of a spreadsheet function is:

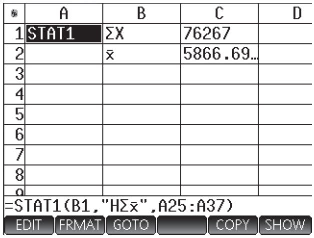
```
functionName(output,“configuration”,
input, [optional parameters])
```

- `Output` is either a reference to a single cell, in which case the output is controlled by the configuration string, or a cell range reference where the output size is restricted by the size of the range. If the output range is wider than it is tall, it will change the output to horizontal layout instead of the default vertical layout.
- `Configuration` is a string that controls which values are output. Leaving the quotation marks empty (“”) produces the default output. The order of the values can also be controlled by the order that they appear in the string.
- `Input` is the input list for the function. This can be a cell range reference, a simple list or anything that results in a list of values.
- `[ ]` denotes optional parameters.

For example: `=STAT1(B1,””,A25:A37)` produces the following output.



For example: =STAT1(B1,”HΣx̄”,A25:A37) produces the following output.



SUM

Calculates the sum of a range of numbers.

SUM([input])

For example, AVERAGE)B7:B23) returns the arithmetic mean of the numbers in the range B7 to B23. You can also specify a block of cells, as in AVERAGE(B7:C23).

An error is returned if a cell in the specified range contains a non-numeric object.

AVERAGE

Calculates the arithmetic mean of a range of numbers.

AVERAGE([input])

For example, AVERAGE)B7:B23) returns the arithmetic mean of the numbers in the range B7 to B23. You can also specify a block of cells, as in AVERAGE)B7:C23).

An error is returned if a cell in the specified range contains a non-numeric object.

AMORT

Calculates the principal, interest, and balance of a loan over a specified period.

```
AMORT(Range, "configuration", n, i, pv,
pmt[ppyr=12, cpyr=ppyr, Grouping=ppyr,
beg=false, fix=current])
```

- Range is the cell range where the results will be placed. If only one cell is specified, the range of cells is automatically calculated.
- Configuration is a string that determines what information will be provided, in what order, and if a heading is to be provided. An empty string ("") will display all information and all headings. The

configuration codes are listed below. Add H as a prefix to have a heading generated for that information.

h – This column contains the row headers

S – This column contains the start of the period

E – This column contains the end of the period HB,HI

P – This column contains the Principal paid this period

B – This column contains the balance at the end of the period

I – This column contains the interest paid this period

n is the number of periods for the loan,

i is interest rate

pv is the present value

pmt is the per-period payment

- Optional parameters:

  ppyr is the number of payments per year

  cpyr is the number of compounding periods per year

- Grouping is the number of periods that need to be grouped together in the amortization table.

  beg is 1 when payment is at the beginning of each period, else it is 0.

  fix is the number of decimal places to be used for the calculations.

Example: `=AMORT(A1,"",12,6,100,200)`

STAT1

he STAT1 function provides a range of one-variable statistics. It can calculate all or any of $\bar{x}$, Σ, Σ², s, s², σ, σ², serr, sqd, n, min, q1, med, q3, and max.

```
STAT1(output,"configuration",input,
[mode])
```

- Output is the cell range where the results are placed. If only one cell is specified, then the range of cells is automatically calculated.
- Configuration is a string that defines if a header row needs to be created (starts with H) and what result to place in which column. An empty string "" will use all the headers.

Note that many of the characters representing statistics—for example, $\bar{x}$ and σ—can be selected from the symbol palette (Shift 9).

- Input is the can be a cell range reference, a simple list or anything that results in a list of values.
- Mode is optional and defines what to calculate the mean of. The valid values are:

  1 = one value
  2 = with frequency data
  3 = with weighted data

  4 = multiplies two data sets together to form a single data set

Examples:

```
STAT1(B1,"",A25:A37)
STAT1(B1,"Hx̄,Hσ",A25:A37)
```

REGRS

Regression analysis function. Can calculate all or any of sl = (slope), int (intercept), cor, cd, sCov, pCov, px (predict x), and py (predict y).

```
REGRS(output, "configuration",
input,[mode],[y],[x])
```

- Output is a reference to where you would like the output to be placed. Note, if a range is specified, it will limit the size of the output, but can also change the orientation from vertical to horizontal if the range is wider than it is tall.
- Configuration is a string that controls what results are shown and in what order they appear. An empty string "" will default to show all in default order including headers.
- Input can be a cell range reference, a simple list or anything that results in a list of values.
- Input Parameters:

  mode (optional) specifies the mode to be used for the regression:

  1 linear
  2 logarithmic

3 exponential
4 power
5 inverse
6 logistic
7 quadratic
8 cubic
9 quartic
10 trigonometric

Important: If *px* or *py* are specified, their opposite value must be one of the input values. For example, if *px* is specified in the configuration string then the y-value must be an input parameter and vice versa for *py*.

Example: `REGRS(J1,"",A25:B37,2)`

PredY

PredX

HypZ1mean

The hypothesis test HypZ1mean is a one-sample Z-test for comparing means.

Syntax:

```
HypZ1mean(ouput, "configuration",input
list)
```

```
HypZ1mean(ouput, "configuration", SampMean,
SampSize, NullPopMean, PopStdDev, SigLevel,
Mode)
```

- Output is a reference to where you would like the output to be placed. Note if a range is specified it will limit the size of the output, but can also change the orientation from vertical to horizontal if the range is wider than it is tall.
- Configuration is a string that controls what results are shown and what order they appear in. An empty string "" will default to show all in default order including headers.

  h = if present the header cells will be created
  acc = Accept/Reject

tZ = Test Z
tM = Test Mean
prob = Probability
cZ = Critical Z
cx1 = Critical xbar 1
cx2 = Critical xbar 2
std = Standard deviation

- Input list is the list of input (see Input Parameters below). This can be a range reference, a list of cell references or a simple list of values.
- Input Parameters:

  SampMean:
  SampSize:
  NullPopMean:
  PopStdDev:
  SigLevel:
  Mode: Specifies how to calculate the statistic

    1 = Less than
    2 = Greater than
    3 = Not Equal

Example: XXXXX

HYPZ2mean

The hypothesis test HypZ2mean is a two-sample Z-test for comparing means.

Syntax:

```
HypZ2mean(ouput, "configuration", input list)
```

```
HypZ2mean(ouput, "configuration", SampMean, SampMean2, SampSize,SampSize2, PopStdDev, PopStdDev2,SigLevel, Mode)
```

- Output is a reference to where you would like the output to be placed. Note if a range is specified it will limit the size of the output, but can also change the orientation from vertical to horizontal if the range is wider than it is tall.
- Configuration is a string that controls what results are shown and what order they appear in. An empty string

"" will default to show all in default order including headers.

h = if present the header cells will be created
acc = Accept/Reject
tZ = Test Z
tM = Test Mean
prob = Probability
cZ = Critical Z
cx1 = Critical xbar 1
cx2 = Critical xbar 2
std = Standard deviation

- Input list is the list of input (see Input Parameters below). This can be a range reference, a list of cell references or a simple list of values.
- Input Parameters:

SampMean:
SampMean2:
SampSize:
SampSize2:
PopStdDev:
PopStdDev2:
SigLevel:
Mode: Specifies how to calculate the statistic

1 = Less than
2 = Greater than
3 = Not Equal

Example: XXXXX

HypZ1prop The hypothesis test HypZ1prop is a one-proportion Z-test.

Syntax:

```
HypZ1prop(output, "configuration", input
list) HypZ1prop(ouput, "configuration",
SuccCount, SampSize, NullPopProp, SigLevel,
Mode)
```

- Output is a reference to where you would like the output to be placed. Note if a range is specified it will limit the size of the output, but can also change the orientation from vertical to horizontal if the range is wider than it is tall.

- Configuration is a string that controls what results are shown and what order they appear in. An empty string "" will default to show all in default order including headers.

  h = if present the header cells will be created
  acc = Accept/Reject
  tZ = Test Z
  tP prob
  cZ
  cp1
  cp2
  std

- Input list is the list of input (see Input Parameters below). This can be a range reference, a list of cell references or a simple list of values.
- Input Parameters:

  SuccCount:
  SampSize:
  NullPopMean:
  SigLevel:
  Mode: Specifies how to calculate the statistic

  1 = Less than
  2 = Greater than
  3 = Not Equal

Example: XXXXX

HypZ2prop

The hypothesis test HypZ2prop is a two-proportion Z-test for comparing means.

Syntax:

```
HypZ2prop(ouput, "configuration", input
list)
```

```
HypZ2prop(ouput, "configuration",
SuccCount1, SuccCount2, SampSize1,
SampSize2, SigLevel, Mode)
```

- Output is a reference to where you would like the output to be placed. Note if a range is specified it will limit the size of the output, but can also change the orientation from vertical to horizontal if the range is wider than it is tall.
- Configuration is a string that controls what results are shown and what order they appear in. An empty string "" will default to show all in default order including headers.

  h = if present the header cells will be created
  acc = Accept/Reject
  tZ = Test Z
  tPd
  prob
  cZ
  cp1
  cp2
  std
- Input list is the list of input (see Input Parameters below). This can be a range reference, a list of cell references or a simple list of values.
- Input Parameters:

  SuccCount1
  SuccCount2
  SampSize1
  SampSize2
  SigLevel
  Mode: Specifies how to calculate the statistic

    1 = Less than
    2 = Greater than
    3 = Not Equal

Example: XXXXX

HypT1mean

The hypothesis test HypT1mean is a one-sample T-test for comparing means.

Syntax:

```
HypT1mean(ouput, "configuration", input
list)
```

```
HypT1mean(ouput, "configuration", SampMean,
SampStdDev, SampSize, NullPopProp, SigLevel,
Mode)
```

- Output is a reference to where you would like the output to be placed. Note if a range is specified it will limit the size of the output, but can also change the orientation from vertical to horizontal if the range is wider than it is tall.
- Configuration is a string that controls what results are shown and what order they appear in. An empty string "" will default to show all in default order including headers.

  h = if present the header cells will be created
  acc = Accept/Reject
  tT
  tM
  prob
  df
  ct
  cX1
  cX2
- Input list is the list of input (see Input Parameters below). This can be a range reference, a list of cell references or a simple list of values.
- Input Parameters:

  SampMean
  SampStdDev
  SampSize:
  NullPopMean:
  SigLevel:
  Mode: Specifies how to calculate the statistic

  1 = Less than
  2 = Greater than
  3 = Not Equal

Example: XXXXX

HypT2mean The hypothesis test HypT2mean is a two-sample T-test for comparing means.

Syntax:

```
HypT2mean(ouput, "configuration", input
list)
```

```
HypT2mean(ouput, "configuration",
SampMean1, SampMean2,SampStdDev1,
SampStdDev2,SampSize1, SampSize2, pooled,
SigLevel, Mode)
```

- Output is a reference to where you would like the output to be placed. Note if a range is specified it will limit the size of the output, but can also change the orientation from vertical to horizontal if the range is wider than it is tall.
- Configuration is a string that controls what results are shown and what order they appear in. An empty string "" will default to show all in default order including headers.

  h = if present the header cells will be created
  acc = Accept/Reject
  tT
  tM
  prob
  df
  ct
  cX1
  cX2
  stD
- Input list is the list of input (see Input Parameters below). This can be a range reference, a list of cell references or a simple list of values.
- Input Parameters:

  SampMean1
  SampMean2
  SampStdDev1
  SampStdDev2
  SampSize1
  SampSize2
  pooled = 0 == false or 1 == true

SigLevel:
Mode: Specifies how to calculate the statistic

1 = Less than
2 = Greater than
3 = Not Equal

Example: XXXXX

ConfZ1mean

The ConfZ1mean calculates the confidence interval for a one-sample Z-test.

Syntax:

```
ConfZ1mean(ouput, "configuration", input
list)
```

```
ConfZ1mean(ouput, "configuration",
SampMean, SampSize, PopStdDevm ConfLevel)
```

- Output is a reference to where you would like the output to be placed. Note if a range is specified it will limit the size of the output, but can also change the orientation from vertical to horizontal if the range is wider than it is tall.
- Configuration is a string that controls what results are shown and what order they appear in. An empty string "" will default to show all in default order including headers.

  h = if present the header cells will be created
  Z
  zXl
  zXh
  std
- Input list is the list of input (see Input Parameters below). This can be a range reference, a list of cell references or a simple list of values.
- Input Parameters:
  SampMean,
  SampSize,
  PopStdDevm
  ConfLevel

Example: XXXXX

ConfZ2mean The ConfZ2mean calculates the confidence interval for a two-sample Z-test.

Syntax:

```
ConfZ2mean(ouput, "configuration", input
list)
```

```
ConfZ2mean(ouput, "configuration",
SampMean1, SampMean2, SampSize1, SampSize2,
PopStdDev1,PopStdDev2 ConfLevel)
```

- Output is a reference to where you would like the output to be placed. Note if a range is specified it will limit the size of the output, but can also change the orientation from vertical to horizontal if the range is wider than it is tall.
- Configuration is a string that controls what results are shown and what order they appear in. An empty string "" will default to show all in default order including headers.

  h = if present the header cells will be created
  Z
  zXl
  zXh
  zXm
  std
- Input list is the list of input (see Input Parameters below). This can be a range reference, a list of cell references or a simple list of values.
- Input Parameters:

  SampMean1,
  SampMean2,
  SampSize1,
  SampSize2,
  PopStdDev1,
  PopStdDev2,
  ConfLevel

Example: XXXXX

ConfZ1prop

The ConfZ1prop calculates the confidence interval for a one-proportion Z-test.

Syntax:

```
ConfZ1prop(ouput, "configuration", input
list) ConfZ1prop(ouput, "configuration",
SuccCount, SampSize, ConfLevel)
```

- Output is a reference to where you would like the output to be placed. Note if a range is specified it will limit the size of the output, but can also change the orientation from vertical to horizontal if the range is wider than it is tall.
- Configuration is a string that controls what results are shown and what order they appear in. An empty string "" will default to show all in default order including headers.

  h = if present the header cells will be created
  Z
  zXl
  zXh
  zXm
  std
- Input list is the list of input (see Input Parameters below). This can be a range reference, a list of cell references or a simple list of values.
- Input Parameters:

  SuccCount,
  SampSize,
  ConfLevel

Example: XXXXX

ConfZ2prop

The ConfZ1mean calculates the confidence interval for a two-proportion Z-test.

Syntax:

```
ConfZ2prop(ouput, "configuration", input
list)
```

```
ConfZ2prop(ouput, "configuration",
SuccCount1, SuccCount2, SampSize1,
SampSize2,ConfLevel)
```

- Output is a reference to where you would like the output to be placed. Note if a range is specified it will limit the size of the output, but can also change the orientation from vertical to horizontal if the range is wider than it is tall.
- Configuration is a string that controls what results are shown and what order they appear in. An empty string "" will default to show all in default order including headers.

  h = if present the header cells will be created
  Z
  zXl
  zXh
  zXm
  std
- Input list is the list of input (see Input Parameters below). This can be a range reference, a list of cell references or a simple list of values.
- Input Parameters:

  SuccCount1,
  SuccCount2,
  SampSize1,
  SampSize2,
  ConfLevel

Example: XXXXX

ConfT1mean

The ConfT1mean calculates the confidence interval for a one-sample T-test.

Syntax:

```
ConfT1mean(ouput, "configuration", input
list)
```

```
ConfT1mean(ouput, "configuration",
SampMean, SampStdDev, SampSize, ConfLevel)
```

- Output is a reference to where you would like the output to be placed. Note if a range is specified it will limit the size of the output, but can also change the orientation from vertical to horizontal if the range is wider than it is tall.
- Configuration is a string that controls what results are shown and what order they appear in. An empty string "" will default to show all in default order including headers.

  h = if present the header cells will be created
  DF T
  zX;
  zXh
  std
- Input list is the list of input (see Input Parameters below). This can be a range reference, a list of cell references or a simple list of values.
- Input Parameters:

  SampMean,
  SampStdDev,
  SampSize,
  ConfLevel

Example: XXXXX

ConfT2mean The ConfT2mean calculates the confidence interval for a two-sample T-test.

Syntax:

```
ConfT2mean(ouput, "configuration", input
list)
```

```
ConfT2mean(ouput, "configuration",
SampMean, SampMean2, SampStdDev,
SampStdDev2, SampSize, SampSize2, pooled,
ConfLevel)
```

- Output is a reference to where you would like the output to be placed. Note if a range is specified it will limit the size of the output, but can also change the orientation from vertical to horizontal if the range is wider than it is tall.

- Configuration is a string that controls what results are shown and what order they appear in. An empty string "" will default to show all in default order including headers.

  h = if present the header cells will be created
  DF T
  zX;
  zXh
  zXm
  Std

- Input list is the list of input (see Input Parameters below). This can be a range reference, a list of cell references or a simple list of values.
- Input Parameters:

  SampMean,
  SampMean2,
  SampStdDev,
  SampStdDev2,
  SampSize,
  SampSize2,
  pooled,
  ConfLevel

Statistics 1Var app functions

The Statistics 1Var app has three functions designed to work together to calculate summary statistics based on one of the statistical analyses (`H1-H5`) defined in the Symbolic view of the Statistics 1Var app.

Do1VStats

Do1:variable statistics. Performs the same calculations as tapping Stats in the Numeric view of the Statistics 1Var app and stores the results in the appropriate Statistics 1Var app results . *Hn* must be one of the Statistics 1Var app Symbolic view `H1-H5`.

```
Do1VStats(Hn)
```

SetFreq

Set frequency. Sets the frequency for one of the statistical analyses (H1–H5) defined in the Symbolic view of the Statistics 1Var app. The frequency can be either one of the column D0–D9, or any positive integer. *Hn* must be one of the Statistics 1Var app Symbolic view H1–H5. If used, *Dn* must be one of the column D0–D9; otherwise, *value* must be a positive integer.

```
SETFREQ(Hn,Dn)
```

or

```
SETFREQ(Hn,value)
```

SetSample

Set sample data. Sets the sample data for one of the statistical analyses (H1–H5) defined in the Symbolic view of the Statistics 1Var app. Sets the data column to one of the column D0–D9 for one of the statistical analyses H1–H5.

```
SETSAMPLE(Hn,Dn)
```

Statistics 2Var app functions

The Statistics 2Var app has a number of functions. Some are designed to calculate summary statistics based on one of the statistical analyses (S1–S5) defined in the Symbolic view of the Statistics 2Var app. Others predict X- and Y-values based on the fit specified in one of the analyses.

PredX

Predict X. Uses the fit from the first active analysis (S1–S5) found to predict an x-value given the y-value.

```
PredX(value)
```

PredY

Predict Y. Uses the fit from the first active analysis (S1–S5) found to predict a y-value given the x-value.

```
PredY(value)
```

Resid

Residuals. Calculates a list of residuals, based on column data and a fit defined in the Symbolic view via S1-S5.

`Resid(Sn)` or `Resid()`

Resid() looks for the first defined analysis in the Symbolic view (S1-S5).

Do2VStats

Do 2:variable statistics. Performs the same calculations as tapping Stats in the Numeric view of the Statistics 2Var app and stores the results in the appropriate Statistics 2Var app results . Sn must be one of the Statistics 2Var app Symbolic view `S1-S5`.

```
Do2VStats(Sn)
```

SetDepend

Set dependent column. Sets the dependent column for one of the statistical analyses `S1-S5` to one of the column `C0-C9`.

```
SetDepend(Sn,Cn)
```

SetIndep

Set independent column. Sets the independent column for one of the statistical analyses S1-S5 to one of the column `C0-C9`.

```
SetIndep(Sn,Cn)
```

Inference app functions

The Inference app has a single function that returns the same results as tapping Calc in the Numeric view of the Inference app. The results depend on the contents of the Inference app `Method`, `Type`, and `AltHyp`.

DoInference

Calculate confidence interval or test hypothesis. Performs the same calculations as tapping Calc in the Numeric view of the Inference app and stores the results in the appropriate Inference app results.

```
DoInference()
```

HypZ1mean

HypZ2mean

HypZ1prop

HypZ2prop

HypT1mean

HypT2mean

ConfZ1mean

ConfZ2mean

ConfZ1Prop

ConfZ2Prop

ConfT1mean

ConfT2mean

Finance app functions

The Finance App uses a set of functions that all reference the same set of Finance app . There are 5 main TVM , 4 of which are mandatory for each of these functions (except `DoFinance`). There are 3 other that are optional and have default values. These occur as arguments to the Finance app functions in the following set order:

- `NbPmt`—the number of payments
- `IPYR`—the annual interest rate
- `PV`—the present value of the investment or loan
- `PMTV`—the payment value
- `FV`—the future value of the investment or loan
- `PPYR`—the number of payments per year (12 by default)

– CPYR—the number of compounding periods per year (12 by default)

– END—payments made at the end of the period

The arguments PPYR, CPYR, and END are optional; if not supplied, PPYR=12, CPYR=PPYR, and END=1.

CalcFV Solves for the future value of an investment or loan.

```
CalcFV(NbPmt,IPYR,PV,PMTV[,PPYR,CPYR,END]
```

CalcIPYR Solves for the interest rate per year of an investment or loan.

```
CalcIPYR(NbPmt,PV,PMTV,FV[,PPYR,CPYR,
END])
```

CalcNbPmt Solves for the number of payments in an investment or loan.

```
CalcNbPmt(IPYR,PV,PMTV,FV[,PPYR,CPYR,END])
```

CalcPMTV Solves for the value of a payment for an investment or loan.

```
CalcPMTV(NbPmt,IPYR,PV,FV[,PPYR,CPYR,END])
```

CalcPV Solves for the present value of an investment or loan.

```
CalcPV(NbPmt,IPYR,PMTV,FV[,PPYR,CPYR,END])
```

DoFinance Calculate TVM results. Solves a TVM problem for the variable *TVMVar*. The variable must be one of the Finance app's Numeric view . Performs the same calculation as tapping Solve in the Numeric view of the Finance app with *TVMVar* highlighted.

```
DoFinance(TVMVar)
```

Example:

DoFinance(FV) returns the future value of an investment in the same way as tapping Solve in the Numeric view of the Finance app with FV highlighted.

Linear Solver app functions

The Linear Solver app has 3 functions that offer the user flexibility in solving 2x2 or 3x3 linear systems of equations.

Solve2x2 Solves a 2x2 linear system of equations.

Solve2x2(*a*, *b*, *c*, *d*, *e*, *f*)

Solves the linear system represented by:

ax+by=c

dx+ey=f

Solve3x3

Solves a 3x3 linear system of equations.

`Solve3x3`(*a, b, c, d, e, f, g, h, i, j, k, l*)

Solves the linear system represented by:

ax+by+cz=d

ex+fy+gz=h

ix+jy+kz=l

LinSolve

Solve linear system. Solves the 2x2 or 3x3 linear system represented by matrix.

`LinSolve(`*matrix*)

Example:

`LinSolve`([[`A, B, C`], [`D, E,F`]]) solves the linear system:

ax+by=c

dx+ey=f

Triangle Solver app functions

The Triangle Solver app has a group of functions which allow solving a complete triangle from the input of three consecutive parts of the triangle. The names of these commands use A to signify an angle, and S to signify a side length. To use these commands, enter three inputs in the specified order given by the command name. These commands all return a list of six items consisting of the three arguments entered with the command and the three unknown values (lengths of sides and measures of angles).

AAS

AAS Uses the measure of two angles and the length of the non-included side to calculate the measure of the third angle and the lengths of the other two sides. Returns all 6 values.

`AAS(angle,angle,side)`

ASA

ASA Uses the measure of two angles and the length of the included side to calculate the measure of the third angle and the lengths of the other two sides. Returns all 6 values.

`ASA(angle,side,angle)`

SAS SAS Uses the length of two sides and the measure of the included angle to calculate the length of the third side and the measures of the other two angles. Returns all 6 values.

`SAS(side,angle,side)`

SSA SSA Uses the lengths of two sides and the measure of a non-included angle to calculate the length of the third side and the measures of the other two angles. Returns all 6 values.

`SSA(side,side,angle)`

SSS SSS Uses the lengths of the three sides of a triangle to calculate the measures of the three angles.

`SSS(side,side,side)`

DoSolve Solves the current problem in the Triangle Solver app. The Triangle Solver app must have enough data entered to successfully solve that is, there must be at least three values entered, one of which must be a side length.

`DoSolve()`

Example:

In Degree mode, `SAS(2,90,2)` returns `{45,2.82…,45}`.

In the indeterminate case `AAS` where two solutions may be possible, `AAS` may return a list of two such lists containing both results.

Linear Explorer functions

SolveForSlope

SolveForYIntercept

Quadratic Explorer functions

SOLVE

DELTA

Geometry app function

GeoAppFunction

Common app functions

In addition to the app functions specific to each app, there are two functions common to the following apps:

- Function
- Solve
- Parametric
- Polar
- Sequence
- Advanced Graphing

CHECK

Checks—that is, selects—the Symbolic view variable `Symbn`. `Symbn` can be any of the following:

- `F0-F9`—for the Function app
- `E0-E9`—for the Solve app
- `H1-H5`—for the Statistics 1Var app
- `S1-S5`—for the Statistics 2Var app
- `X0/Yo-X9/Y9`—for the parametric app
- `R0-R9`—for the Polar app
- `U0-U9`—for the Sequence app

`CHECK(Symbn)`

Example:

`CHECK(F1)` checks the Function app Symbolic view variable F1. The result is that F1(X) is drawn in the Plot view and has a column of function values in the Numeric view of the Function app.

UNCHECK

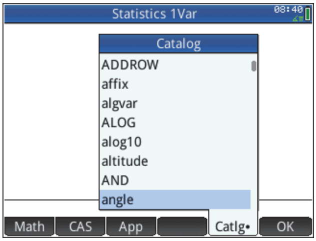
Unchecks the Symbolic view variable `Symbn`.

`UNCHECK(Symbn)`

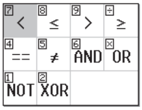
Example:

`UNCHECK(R1)` unchecks the Polar app Symbolic view variable R1. The result is that R1(θ) is not drawn in the Plot view and does not appear in the Numeric view of the Polar app.

Ctlg menu



The Catlg menu brings together all the functions and commands available on the HP Prime. However, this section describes the functions and commands that can only be found on the Catlg menu. The functions and commands that are also on the Math menu are described in “Keyboard functions” on page 285. Those that are also on the CAS menu are described in “CAS menu” on page 298. The functions and commands specific to the Geometry app are described in “Geometry functions and commands” on page 151, and those specific to programming are described in “Program commands” on page 464.



Some of the options on the Catlg menu can also be chosen from relations palette (Shift 9)

(Inserts opening parenthesis.

***** Multiplication symbol. Returns the product of numbers or the scalar product of two vectors.

+ Addition symbol. Returns the term-by-term sum of two lists or two matrices, or adds two strings together.

– Subtraction symbol. Returns the term-by-term subtraction of two lists or two matrices.

.* List or matrix multiplication symbol. Returns the term-by-term multiplication of two lists or two matrices.

./ List or matrix division symbol. Returns the term-by-term division of two lists or two matrices.

.^ Returns the list or matrix where each term is the corresponding term of the list or matrix given as argument, raised to the power *n*.

`.^(Lst or Mtrx,Intg(n))`

:= Stores the evaluated expression in the variable. Note that `:=` cannot be used with the graphics G0–G9. See the command `BLIT`.

`var:=expression`

< Strict inequality test. Returns 1 if the inequality is true, and 0 if the inequality is false. Note that more than two objects can be compared. Thus 6 < 8 < 11 returns 1 (because it is true) whereas 6 < 8 < 3 returns 0 (as it is false).

<= Inequality test. Returns 1 if the inequality is true, and 0 if the inequality is false. Note that more than two objects can be compared. See comment above regarding <.

<> Inequality test. Returns 1 if the inequality is true, and 0 if the inequality is false.

= Equality symbol. Connects two members of an equation.

== Equality test. Returns 1 if the equality is true, and 0 if the equality is false.

> Strict inequality test. Returns 1 if the inequality is true, and 0 if the inequality is false. Note that more than two objects can be compared. See comment above regarding <.

>= Inequality test. Returns 1 if the inequality is true, and 0 if the inequality is false. Note that more than two objects can be compared. See comment above regarding <.

^ Inserts the power symbol.

a2q Returns the symbolic expression in quadratic form in the given in VectVar of the symmetric matrix A.

`a2q(MtrxA,VectVar)`

abcuv Returns the polynomials U and V such that for polynomials A, B and C, PU+QV=R. With only polynomials as arguments, the variable used is *x*. With a variable as the final argument, the polynomials are expressions of it.

`abcuv(Poly(A),Poly(B),Poly(C),[Var])`

ACOS Arc cosine: $\cos^{-1}x$.

`ACOS(`*`value`*`)`

additionally Used in programming with `assume` to state an additional assumption about a variable.

```
assume(n,integer);
```

```
additionally(n>5);
```

algvar Returns the list of the symbolic variable names used in an expression. The list is ordered by the algebraic extensions required to build the original expression.

```
algvar(Expr)
```

alog10 Returns the solution when 10 is taken to the power of an expression.

```
alog10(Expr)
```

altitude Draws the altitude through A of the triangle ABC.

```
altitude(Pnt or Cplx(A),Pnt or Cplx(B),Pnt or
Cplx(C))
```

AND Logical And.

expr1 `AND` *expr2*

Example:

`3+1==4 AND 4 < 5` returns `1`.

angleatraw Displays the value of the measure of the angle AB-AC at point z0.

```
angleatraw(Pnt(A),Pnt(B),Pnt(C),(Pnt or
Cplx(z0)))
```

Ans If n>=0, returns the (*n*+1)th answer in the command history. If n<0, returns the (–n)th previous answer. If no *n* is provided, returns the previous answer.

```
ans(Intg(n))
```

append Appends an element to a list, sequence or set.

```
append((Lst||Seq||Set,Elem)
```

apply Returns the result of applying a function to the elements in a list.

```
apply(Fnc,Lst)
```

approx With one argument, returns the numerical evaluation of it. With a second argument, returns the numerical evaluation of the first argument with the number of significant figures taken from the second argument.

`approx(Expr,[Int])`

areaat Displays the algebraic area at point z0 of a circle or a polygon. A legend is provided.

`areaat(Polygon,Pnt||Cplx(z0))`

areaatraw Displays the algebraic area at point z0 of a circle or a polygon.

`areaatraw(Polygone,Pnt||Cplx(z0))`

ASIN Arc sine: $\text{sine}^{-1}x$.

`ASIN(`*`value`*`)`

assume Used in programming to state an assumption about a variable.

`assume(Expr)`

ATAN Arc tan: $\tan^{-1}x$.

`ATAN(`*`value`*`)`

barycenter Draws the barycenter of the system consisting of point 1 with weight coefficient 1, point 2 with weight coefficient 2, point 3 with weight coefficient 3, etc.

```
barycenter([Pnt1,Coeff1],[Pnt2,Coeff2],[Pnt3,
Coeff3])
```

basis Returns the basis of the linear subspace defined by the set of vectors consisting of vector 1, vector 2,..., and vector *n*.

`basis(Lst(vector1,...,vectorn))`

BEGIN Used in programming to begin a set of statements that should be taken as a single statement.

bisector Draws the bisector of the angle AB-AC.

```
bisector((Pnt(A) or Cplx),(Pnt(B) or
Cplx),Pnt(C) or Cplx))
```

black Used with `display` to specify the color of the geometrical object to be displayed.

blue Used with `display` to specify the color of the geometrical object to be displayed.

bounded_function What does this one do?

BREAK Used in programming to interrupt a loop.

breakpoint Used in programming to insert an intentional stopping or pausing point.

canonical_form Returns a second degree trinomial in canonical form.

```
canonical_form(Trinom(a*x^2+b*x+c),[Var])
```

cat Evaluates the objects in a sequence, then returns them concatenated as a string.

```
cat(SeqObj)
```

center Displays a circle with its center indicated.

```
center(Crcle)
```

cFactor Returns an expression factorized over the complex field (on Gaussian integers if there are more than two).

```
cfactor(Expr)
```

charpoly Returns the coefficients of the characteristic polynomial of a matrix. With only one argument, the variable used in the polynomial is *x*. With a variable as second argument, the polynomial is an expression of it.

```
charpoly(Mtrx,[Var])
```

chrem Returns the Chinese remainders for two lists of integers.

```
chrem(LstIntg(a,b,c....),LstIntg(p,q,r,....))
```

circle With two arguments, draws a circle. If the second argument is a point, then the distance between it and the point given as the first argument is equal to the diameter the circle. If the second argument is a complex, then the center of the circle is at the point given in the first argument and the absolute value of the second argument is the radius of the circle.

```
circle((Pnt or Cplx(A)),(Pnt or
Cplx(B)),[Real(a)],[Real(b)],[Var(A)],[Var(B)
])
```

circumcircle Returns the circumcircle of the triangle ABC.

```
circumcircle((Pnt or Cplx(A)),(Pnt or
Cplx(B)),((Pnt or Cplx(C)))
```

col Returns the column of index *n* of a matrix.

```
col(Mtrx,n)
```

colDim Returns the number of columns of a matrix.

```
colDim(Mtrx)
```

comDenom Rewrites a sum of rational fractions as a one rational fraction. The denominator of the one rational fraction is the common denominator of the rational fractions in the original expression. With a variable as second argument, the numerator and denominator are developed according to it.

```
comDenom(Expr,[Var])
```

common_perpendicular Draws the common perpendicular of the lines D1 and D2.

```
common_perpendicular(Line(D1),Line(D2))
```

companion Returns the companion matrix of a polynomial.

```
companion(Poly,Var)
```

compare Compares objects, and returns 1 if type(arg1)<type(arg2) or if type(arg1)=type(arg2) and arg1<arg2, and returns 0 otherwise.

```
compare(Obj(arg1),Obj(arg2))
```

complexroot With two arguments, returns vectors, each of which is either a complex root of the polynomial P with its multiplicity or an interval the boundaries of which are the opposite vertices of a rectangle with sides parallel to the axis and containing a complex root of the polynomial with the multiplicity of this root. With four arguments, returns vectors described as for two arguments, but only for those roots lying in the rectangle with sides parallel to the axis having complex *a* and complex *b* as opposite vertices

```
complexroot(Poly(P),Real(l),[Cplx(a)],[Cplx(b
)])
```

cone Draws a cone with vertex at A, direction given by v, half angle t, and, if provided, height h and –h.

```
cone(Pnt(A),Vect(v),Real(t),[Real(h)])
```

conic Defines a conic from an expression and draws it. Without a second argument, *x* and *y* are taken as the default .

```
conic(Expr,[LstVar])
```

contains Returns 1 if a list or set contains an element, and 0 if the list or set does not contain the element.

```
contains((Lst(l) or Set(l)),Elem(e))
```

CONTINUE Used in programming to bypass remaining statements in the current iteration and begin the next iteration in a loop.

CONVERT Returns the value of an expression subjected to a command.

`convert(Expr,Cmd)`

convexhull Returns the convex hull of a list of two-dimensional points.

`convexhull(Lst)`

CopyVar Copies the first variable into the second variable without evaluation.

`CopyVar(Var1,Var2)`

correlation Returns the correlation of the elements of a list or matrix.

`correlation(Lst||Mtrx)`

COS Cosine: cos*x*.

`COS(`*`value`*`)`

count Applies a function to the elements in a list or matrix and returns their sum.

`count(Fnc,(Lst||Mtrx))`

covariance Returns the covariance of the elements in a list or matrix.

`covariance(Lst||Mtrx)`

covariance_correlatio Returns the list of the covariance and the correlation of the elements of a list or matrix.

`covariance_correlation(Lst||Mtrx)`

cpartfrac Returns the result of partial fraction decomposition of a rational fraction in the complex field.

`cpartfrac(RatFrac)`

crationalroot Returns the list of complex rational roots of a polynomial without indicating the multiplicity.

`crationalroot(Poly)`

cube Draws a cube with a vertex at the line AB and a face in the plane containing A,B, and C.

`cube(Pnt(A),Pnt(B),Pnt(C))`

cumSum Returns the list, sequence or string whose elements are the cumulative sum of the original list, sequence or string.

`cumSum(Lst||Seq||Str)`

cyan Used with `display` to specify the color of the geometrical object to be displayed.

cylinder Draws a cylinder with axis from A in the direction of vector v, with radius r, and, if provided, with height h.

```
cylinder(Pnt(A),Vect(v),Real(r),[Real(h)])
```

DEBUG Starts the debugger for the program name you specify. In a program, `DEBUG( )` will act as a breakpoint and launch the debugger at that location. This allows you to start debugging at a specific location, rather than starting at the beginning of the program.

```
debug(program_name)
```

delcols Returns the matrix that is matrix A with the columns n1...nk deleted.

```
delcols(Mtrx(A),Interval(n1...nk)||n1)
```

delrows Returns the matrix that is matrix A with the rows n1...nk deleted.

```
delrows(Mtrx(A),Interval(n1..n2)||n1)
```

deltalist Returns the list of the differences between consecutive terms in the original list.

```
deltalist(Lst)
```

Dirac Returns the value of the Dirac delta function for a real number.

```
Dirac(Real)
```

division_point Returns a point M such that for the given *a* and *b*, (z–a)=k*(z–b) and z=MA=k*MB.

```
division_point(Pnt or Cplx(a),Pnt or
Cplx(b),Cplx(k))
```

DO Used in programming to initiate a step or sequence of steps.

DrawSlp Draws the line with slope m that goes through the point (a,b) (i.e. y–b=m(x–a)).

```
DrawSlp(Real(a),Real(b),Real(m))
```

e Enters the mathematical constant e (Euler's number).

egcd Returns three polynomials U, V and D such that for two polynomials A and B:

U(x)*A(x)+V(x)*B(x)=D(x)=GCD(A(x),B(x))

(where GCD(A(x),B(x) is the greatest common divisor of polynomials A and B).

The polynomials can be provided in symbolic form or as lists. Without a third argument, it is assumed that the polynomials are expressions of *x*. With a variable as third argument, the polynomials are expressions of it.

```
egcd((Poly or Lst(A)),(Poly or Lst(B)),[Var])
```

eigenvals Returns the sequence of eigenvalues of a matrix.

```
eigenvals(Mtrx)
```

eigenvects Returns the eigenvectors of a diagonalizable matrix..

```
eigenvects(Mtrx)
```

eigVc Returns the eigenvectors of a diagonalizable matrix.

```
eigVc(Mtrx)
```

eigVl Returns the Jordan matrix associated with a matrix when the eigenvalues are calculable.

```
eigVl(Mtrx)
```

element Shows a point on a curve or a real in an interval.

```
element((Curve or Real_interval),(Pnt or
Real))
```

ellipse With three points (F1, F2, and M) as arguments, draws an ellipse with foci at F1 and F2 that passes though M. With two points and a real (F1, F2, and a) as arguments, draws an ellipse with foci at F1 and F2 that passes through point M such that MF1+MF2=2a. With one second degree polynomial p(x,y) as argument, draws the ellipse defined when the polynomial is set to equal 0.

```
ellipse(Pnt(F1),Pnt(F2),(Pnt(M) or Real(a))
```

or

```
ellipse(p(x,y))
```

ELSE Used in programming to introduce the false clause in a conditional statement.

END Used in programming to end a set of statements that should be taken as a single statement.

equilateral_triangle With three arguments, draws the equilateral triangle ABC of side AB. With four arguments, draws the equilateral triangle ABC in the plane ABP.

```
equilateral_triangle((Pnt(A) or Cplx),(Pnt(B)
or Cplx),[Pnt(P)],[Var(C)])
```

EVAL Evaluates an expression.

```
eval(Expr)
```

evalc Returns an complex expression written in the form real+i*imag.

```
evalc(Expr)
```

evalf With one argument, returns the numerical evaluation of it. With a second argument, returns the numerical evaluation of the first argument with the number of significant figures taken from the second argument.

```
evalf(Expr,[Int])
```

exact Converts an irrational expression to a rational or real expression.

```
exact(Expr)
```

exbisector Draws the exterior bisector of the angle AB-AC given by A,B, and C.

```
exbisector((Pnt or Cplx(A)),(Pnt or
Cplx(B)),(Pnt or Cplx(C)))
```

excircle Draws the excircle of the triangle ABC.

```
excircle((Pnt or Cplx(A)),(Pnt or
Cplx(B)),(Pnt or Cplx(C)))
```

EXP Returns the solution to the mathematical constant e to the power of an expression.

```
exp(Expr)
```

exponential_ regression Returns the coefficients (a,b) of y=b*a^x, where y is the exponential which best approximates the points whose coordinates are the elements in two lists or the rows of a matrix.

```
exponential_regression(Lst||Mtrx(A),[Lst])
```

EXPORT Export. Exports the function `FunctionName` so that it is globally available and appears on the User menu (Mem User).

```
EXPORT(FunctionName)
```

EXPR Parses the string *str* into a number or expression.

expr (*str*)

Examples:

`expr("2+3")` returns `5`.

`expr("X+10")` returns `100`.

(If the variable *X* has the value 90)

ezgcd Uses the EZ GCD algorithm to return the greatest common divisor of two polynomials with at least two .

```
ezgcd(Poly,Poly)
```

f2nd Returns a list consisting of the numerator and denominator of an irreducible form of a rational fraction.

```
f2nd(RatFrac)
```

faces Returns the list of the faces of a polygon or polyhedron. Each face is a matrix of *n* rows and three columns (where *n* is the number of vertices of the polygon or polyhedron).

```
faces(Polygon or Polyedr)
```

factorial Returns the factorial of an integer or the solution to the gamma function for a non-integer.

```
factorial(Intg(n)||Real(a))
```

fMax Returns the value of the abscissa at the maximum value of an expression. Without a second argument, it is assumed that it the abscissa is *x*. With a variable as second argument, it is taken as the abscissa.

```
fMax(Expr,[Var])
```

fMin Returns the value of the abscissa at the minimum value of an expression. Without a second argument, it is assumed that it the abscissa is *x*. With a variable as second argument, it is taken as the abscissa.

```
fMin(Expr,[Var])
```

FOR Used in programming in loops for which the number of iterations is known.

format Returns a real number as a string with the indicated format (f=float, s=scientific, e=engineering).

```
format(Real,Str("f4"||"s5"||"e6"))
```

fracmod For a given integer *n* (representing a fraction) and an integer *p* (the modulus), returns the fraction *a/b* such that *n=a/b*(mod *p*).

```
fracmod(Intg(n),Intg(p))
```

froot Returns the list of roots and poles of a rational polynomial. Each root or pole is followed by its multiplicity.

```
froot(RatPoly)
```

fsolve Returns the numerical solution of an equation or a system of equations. With the optional third argument you can specify a guess for the solution or an interval within which it is expected that the solution will occur. With the optional fourth argument you can name the iterative algorithm to be used by the solver.

```
fsolve(Expr,Var,[Guess or Interval],[Method])
```

function_diff Returns the derivative function of a function.

```
function_diff(Fnc)
```

gauss Using the Gauss algorithm, returns the quadratic form of an expression written as a sum or difference of squares of the given in VectVar.

```
gauss(Expr,VectVar)
```

GETPIX_C Returns the color of the pixel *G* with coordinates *x,y*.

```
GETPIX_P([G], xposition, yposition)
```

G can be any of the graphics and is optional. The default is *G0*, the current graphic.

GF Creates a Galois Field of characteristic *p* with *p*^*n* elements.

```
GF(Intg(p),Intg(n))
```

gramschmidt For a basis B of a vector subspace, and a function Sp that defines a scalar product on this vector subspace, returns an orthonormal basis for Sp.

```
gramschmidt(Basis(B),ScalarProd(Sp))
```

green Used with `display` to specify the color of the geometrical object to be displayed.

half_cone Draws a half-cone with vertex A, direction v, half angle t and, if applicable, height h.

```
half_cone(Pnt(A),Vect(v),Real(t),[Real(h)])
```

half_line Draws the half-line AB with A as the origin.

```
half_line((Pnt or Cplx(A)),(Pnt or Cplx(B)))
```

halftan2hypexp Returns an expression with sin(*x*), cos(*x*), tan(*x*) rewritten in terms of tan(*x*/2) and sinh(x), cosh(x), tanh(x) rewritten in terms of exp(*x*).

```
halftan_hyp2exp(ExprTrig)
```

halt Used in programming to go into step-by-step debugging mode.

hamdist Returns the Hamming distance between two integers.

```
hamdist(Intg,Intg)
```

harmonic_conjugate Returns the harmonic conjugate of three points or of three parallel or concurrent lines, or returns the line of conjugates of a point with respect to two lines.

```
harmonic_conjugate(Line or Pnt,Line or
Pnt,Line or Pnt)
```

harmonic_division With three points and a variable as arguments, returns four points that are in a harmonic division. With three lines and a variable as arguments, returns four lines that are in a harmonic division.

```
harmonic_division(Pnt or Line,Pnt or Line,Pnt
or Line,Var)
```

has Returns 1 if a variable is in an expression, and returns 0 otherwise.

```
has(Expr,Var)
```

head Returns the first element of a given vector, sequence or string.

```
head(Vect or Seq or Str)
```

Heaviside Returns the value of the Heaviside function for a given real (i.e. 1 if x>=0, and 0 if x<0).

```
Heaviside(Real)
```

hexagon Draws a hexagon of side AB in the plane ABP. The other four corners of the hexagon are named according to the given in the third, fourth, fifth and sixth arguments.

```
hexagon(Pnt or Cplx(A),Pnt or
Cplx(B),[Pnt(P)],[Var(C)],[Var(D)],[Var(E)],[
Var(F)])
```

homothety Returns a point A1 such that vect(C,A1)=k*vect(C,A).

```
homothety(Pnt(C),Real(k),Pnt(A))
```

hyp2exp Returns an expression with hyperbolic terms rewritten as exponentials.

```
hyp2exp(ExprHyperb)
```

hyperbola With three points (F1, F2, and M) as arguments, draws an hyperbola with foci at F1 and F2 that passes though M. With two points and a real (F1, F2, and a) as arguments, draws an hyperbola with foci at F1 and F2 that passes through point M such that |MF1–MF2|=2a. With one second degree polynomial p(x,y) as argument, draws the hyperbola defined when the polynomial is set to equal 0.

```
hyperbola(Focus(F1),Focus(F2),(Pnt(M) or
Real(a)))
```

iabcuv Returns [u,v] such as au+bv=c for three integers a,b, and c. Note that c must be a multiple of the greatest common divisor of a and b for there to be a solution.

```
iabcuv(Intg(a),Intg(b),Intg(c))
```

ibasis Returns the basis of the intersection of two vector spaces.

```
ibasis(Lst(Vect,..,Vect),Lst(Vect,..,Vect))
```

icontent Returns the greatest common divisor of the integer coefficients of a polynomial.

```
icontent(Poly,[Var])
```

icosahedron Draws an icosahedron with center A, vertex B and such that the plane ABC contains one vertex among the five nearest vertices from B.

```
icosahedron(Pnt(A),Pnt(B),Pnt(C))
```

id Returns the solution to the identity function for an expression.

```
id(Seq)
```

identity Returns the identity matrix of dimension *n*.

```
identity(Intg(n))
```

iegcd Returns the extended greatest common divisor of two integers.

```
iegcd(Intg,Intg)
```

IF Used in programming to begin a conditional statement.

IFERR Executes sequence of *commands1*. If an error occurs during execution of *commands1*, execute sequence of *commands2*. Otherwise, execute sequence of *commands3*.

```
IFERR commands1 THEN commands2 [ELSE
commands3] END;
```

IFTE If a condition is satisfied, returns Expr1, otherwise returns Expr2.

```
IFTE(Cond,Expr1,Expr2)
```

igcd Returns the greatest common divisor of two integers or two rationals or two polynomials of several .

```
igcd((Intg(a) or Poly),(Intg(b) or Poly))
```

ilaplace Returns the inverse Laplace transform of a rational fraction.

```
ilaplace(Expr,[Var],[IlapVar])
```

incircle Draws the incircle of triangle ABC.

```
incircle((Pnt or Cplx(A)),(Pnt or
Cplx(B)),(Pnt or Cplx(C)))
```

inter With two curves or surfaces as arguments, returns the intersection of the curves or surfaces as a vector. With a point as the third argument, returns the intersection of the curves or surfaces close to the point.

```
inter(Curve,Curve,[Pnt])
```

interval2center Returns the center of an interval or object.

```
interval2center(Interval or Real)
```

inv Returns the inverse of an expression or matrix.

```
inv(Expr||Mtrx)
```

inversion Returns point A1 such that A1 is on line CA and mes_alg(CA1*CA)=k.

```
inversion(Pnt(C),Real(k),Pnt(A))
```

iPart Returns a real number without its fractional part or a list of real numbers each without its fractional part.

```
iPart(Real||LstReal)
```

iquorem Returns the Euclidean quotient and remainder of two integers.

```
iquorem(Intg(a),Intg(b))
```

isobarycenter Draws the isobarycenter of the given points.

```
isobarycenter((Pnt or Cplx),(Pnt or Cplx),(Pnt
or Cplx))
```

isopolygon With two points and n>0, draws a regular polygon with vertices at the two points and abs(n) vertices in total. With three points and n>0, draws a regular polygon with vertices at the first two points and the third point is in the plane of the polygon. With two points and n<0, draws a regular polygon with center at the first point and a vertex at the second point.

With three points and n<0, draws a regular polygon with center at the first point, vertex at the second point and the third point is a point in the plane of the polygon.

```
isopolygon(Pnt,Pnt,[Pnt],Intg(n))
```

isosceles_triangle Draws the isosceles triangle ABC. With an angle (t) as the third argument, it is equal to angle AB-AC. With a point (P) as the third argument, the triangle is in the plane formed by A, B and P, and angle AB-AC is equal to angle AB-AP. With a list consisting of a point and an angle as the third argument (t,P), the triangle is in the plane formed by A, B and P, and the angle AB-AC is equal to t.

```
isosceles_triangle((Pnt or Cplx(A)),(Pnt or
Cplx(B)),(Angle(t) or Pnt(P) or
Lst(P,t)),[Var(C)])
```

jacobi_symbol Returns the Jacobi symbol of the given integers.

```
jacobi_symbol(Intg,Intg)
```

KILL Used in programming to stop a step-by-step execution with debugging.

laplacian Returns the Laplacian of an expression with respect to a list of .

```
laplacian(Expr,LstVar)
```

lcoeff Returns the coefficient of the term of highest degree of a polynomial. The polynomial can be expressed in symbolic form or as a list.

```
lcoeff(Poly||Lst)
```

legendre_symbol Returns the Legendre symbol of the given integers.

```
legendre_symbol(Intg,Intg)
```

length Returns the length of a list, string or sequence.

```
length(Lst or Str or Seq)
```

lgcd Returns the greatest common divisor of a list of integers or polynomials.

```
lgcd(Seq or Lst)
```

lin Returns an expression with the exponentials linearized.

```
lin(Expr)
```

line_segments Returns the list of the line segments (one line=one segment) of a polyhedron.

```
line_segments(Polygon or Polyedr(P))
```

linear_interpolate Takes a regular sample from a polygonal line defined by a matrix of two rows.

```
linear_interpolate(Mtrx,xmin,xmax,xstep)
```

linear_regression Returns the coefficients a and b of y=a*x+b, where y is the line that best approximates the points whose coordinates are the elements in two lists or the rows of a matrix.

```
linear_regression(Lst||Mtrx(A),[Lst])
```

LineHorz Draws the horizontal line y=a.

```
LineHorz(Expr(a))
```

LineTan Draws the tangent to y=f(x) at x=a.

```
LineTan(Expr(f(x)),[Var],Expr(a))
```

LineVert Draws the vertical line x=a.

```
LineVert(Expr(a))
```

list2mat Returns a matrix of *n* columns made by splitting a list into rows each containing n terms. If the number of elements in the list is not divisible by n, then the matrix is completed with zeros.

```
list2mat(Lst(l),Intg(n))
```

LN Returns the natural logarithm of an expression.

```
ln(Expr)
```

lname Returns a list of the in an expression.

```
lname(Expr)
```

lnexpand Returns the expanded form of a logarithmic expression.

```
lnexpand(Expr)
```

LOCAL Used in programming to define local .

```
LOCAL var1,var2,…varn
```

locus locus(M,A) draws the locus of M.

locus(d,A) draws the envelope of d.

A:=element(C) (C is a curve).

```
locus(Pnt,Elem)
```

LOG Returns the natural logarithm of an expression.

```
LOG(Expr)
```

log10 Returns the log base 10 of an expression.

`log10(Expr)`

logarithmic_ regressio Returns the coefficients a and b of y=a*ln(x)+b, where y is the natural logarithm that best approximates the points whose coordinates are the elements in two lists or the rows of a matrix.

`logarithmic_regression(Lst||Mtrx(A),[Lst])`

logb Returns the logarithm of base *b* of *a*.

`log(a,b)`

logistic_ regression Returns y, y', C, y'max, xmax, and R, where y is a logistic function (the solution of y'/y=a*y+b), such that y(x0)=y0 and where [y'(x0),y'(x0+1)...] is the best approximation of the line formed by the elements in the list L.

`logistic_regression(Lst(L),Real(x0),Real(y0))`

lvar Returns a list of used in an expression.

`lvar(Expr)`

magenta Used with `display` to specify the color of the geometrical object to be displayed.

map Applies a function to the elements of the list.

`map(Lst,Fnc)`

mat2list Returns the list of the terms of a matrix.

`mat2list(Mtrx)`

matpow Calculates the *n*th power of a matrix by jordanization

`matpow(Mtrx,Intg(n))`

MAXREAL Returns the maximum real number that the HP Prime is capable of representing: 9.99999999999E499.

mean Returns the arithmetic mean of a list (with the second argument as pound) or of the columns of a matrix. What does the bit in parentheses mean?

`mean(Lst||Mtrx,[Lst])`

median Returns the median of a list (with the second argument as pound) or of the columns of a matrix. What does the bit in parentheses mean?

`median(Lst||Mtrx,[Lst])`

median_line Draws the median line through A of the triangle ABC.

```
median_line((Pnt or Cplx(A)),(Pnt or
Cplx(B)),(Pnt or Cplx(C)))
```

member Tests if an element is in a list or set. If the element is in the list or set, returns the subsequent element. If the element is not in the list or set, returns 0.

```
member(Elem(e),(Lst(l) or Set(l)))
```

midpoint Draws the midpoint of the line segment AB.

```
midpoint((Pnt or Cplx(A)),(Pnt or Cplx(A)))
```

MINREAL Returns the minimum real number that the HP Prime is capable of representing: 1E4–99.

MKSA Converts a unit object into a unit object written with the compatible MKSA base unit.

```
mksa(Unit)
```

modgcd Uses the modular algorithm to return the greatest common divisor of two polynomials.

```
modgcd(Poly,Poly)
```

mRow Multiplies the row n1 of the matrix A by an expression.

```
mRow(Expr,Mtrx(A),Intg(n1))
```

mult_c_conjugate If the given complex expression has a complex denominator, returns the expression after both the numerator and the denominator have been multiplied by the complex conjugate of the denominator. If the given complex expression does not have a complex denominator, returns the expression after both the numerator and the denominator have been multiplied by the complex conjugate of the numerator.

```
mult_c_conjugate(Expr)
```

mult_conjugate Takes an expression in which the numerator or the denominator contains a square root. If the denominator contains a square root, returns the expression after both the numerator and the denominator have been multiplied by the complex conjugate of the denominator. If the denominator does not contain a square root, returns the expression after both the numerator and the denominator have been multiplied by the complex conjugate of the numerator.

```
mult_conjugate(Expr)
```

nDeriv Returns an approximate value of the derivative of an expression at a given point, using f'(x)=(f(x+h)–f(x+h))/2*h.

Without a third argument, the value of h is set to 0.001. With a real as third argument, it is the value of h.

```
nDeriv(Expr,Var(var),[Real(h)])
```

NEG Unary minus. Enters the negative sign.

normal Returns the expanded irreducible form of an expression.

```
normal(Expr)
```

normalize Returns a vector divided by its l^2 norm (where the l^2 norm is the square root of the sum of the squares of the vector's coordinates).

```
normalize(Lst||Cplx)
```

NOT Returns the logical inverse of a Boolean expression.

```
not(Boolean)
```

NTHROOT Gives the expression for calculating the *n*th root of a number.

octahedron Draws an octahedron with center A and vertex B and such that the plane ABC contains four vertices.

```
octahedron(Pnt(A),Pnt(B),Pnt(C))
```

odd Returns 1 if a given integer is odd, and returns 0 otherwise.

```
odd(Intg(n))
```

open_polygon Draws a polygonal line with vertices at the elements of the given list.

```
open_polygon(LstPnt||LstCplx)
```

OR Logical Or.

expr1 OR *expr2*

Example:

`3+1==4 OR 8 < 5` returns `1`.

order_size Returns the remainder (O term) of a series expansion: limit(x^a*order_size(x),x=0)=0 if a>0.

```
order_size(Expr)
```

orthocenter Shows the orthocenter of the triangle made with three points.

```
orthocenter((Pnt or Cplx),(Pnt or Cplx),(Pnt
or Cplx))
```

orthogonal With a point (A) and a line (BC) as arguments, draws the orthogonal plane of the line that passes through the point.

With a point (A) and a plane (BCD) as arguments, draws the orthogonal line of the plane that passes through the point.

```
orthogonal(Pnt(A),(Line(BC) or Plane(BCD))
```

pa2b2 Takes a prime integer n congruent to 1 modulo 4 and returns [a,b] such that a^2+b^2=n.

```
pa2b2(Intg(n))
```

pade Returns the Pade approximation i.e. a rational fraction P/Q such that P/Q=Xpr mod x^(n+1) or mod N with degree(P)<p.

```
pade(Expr(Xpr), Var(x), (Intg(n) || Poly(N)),
Intg(p))
```

parabola With two points (F, A) as arguments, draws a parabola of focus F and top A. With three points (F, A and P) as arguments, draws a parabola with focus F and top A in the plane ABP. With a complex (A) and a real (c) as arguments, draws a parabola of equation y=yA+c*(x–xA)^2. With one second degree polynomial (P(x,y)) as argument, draws the parabola when the polynomial is set to equal 0.

```
parabola(Pnt(F)||Pnt(xA+i*yA),Pnt(A)||Real(c)
,[Pnt(P)])
```

parallel With a point and a line as arguments, draws the line through the point that is parallel to the given line. With a point and a plane as arguments, draws the plane through the point that is parallel to the given plane. with a point and two lines as arguments, draws the plane through the point that is parallel to the plane made by the two given lines.

```
parallel(Pnt or Line,Line or Plane,[Line])
```

parallelepiped Draws a parallelepiped with sides AB, AC, and AD. The faces of the parallelepiped are parallelograms.

```
parallelepiped(Pnt(A),Pnt(B),Pnt(C),Pnt(D))
```

parallelogram Draws the parallelogram ABCD such that vector(AB)+vector(AD)=vector(AC).

```
parallelogram(Pnt(A)||Cplx,Pnt(B)||Cplx,Pnt(C
)||Cplx,[Var(D)])
```

perimeterat Displays the perimeter at point z0 of a circle or polygon. A legend is provided.

```
perimeterat(Polygon,Pnt||Cplx(z0))
```

perimeteratraw Displays the perimeter at point z0 of a circle or polygon.

```
perimeteratraw(Polygon,Pnt||Cplx(z0))
```

perpen_bisector Draws the bisection (line or plane) of the segment AB.

```
perpen_bisector((Pnt or Cplx(A)),(Pnt or
Cplx(B)))
```

perpendicular With a point and a line as arguments, returns the line that is orthogonal to the given line and that passes through the given point. With a line and a plane as arguments, draws the plane that is orthogonal to the given plane and that contains the given line.

```
perpendicular((Pnt or Line),(Line or Plane))
```

PI Inserts pi.

PIECEWISE Takes as arguments pairs consisting of a condition and an expression. Each of these pairs defines a subfunction of the piecewise function and the domain over which it is active.

```
piecewise(Cond1,Expr1,..,Cond2p,Expr2p,[Expr2
p+1])
```

plane With three points as arguments, draws the plane made by the three points. With a point and a line as arguments, draws the plane made by the point and the line. With an equation as argument, draws the plane corresponding to the equation in 3D space.

```
plane(Pnt or Eq, [Pnt or Line],[Pnt])
```

plotinequation Draws the points of the plane whose coordinates satisfy the inequations of two

```
plotinequation(Expr,[x=xrange,y=yrange],[xste
p],[ystep])
```

plotparam With a complex (a(t)+i*b(t)) and a list of values for the variable (t) as arguments, draws the parametric representation of the curve defined by x=a(t) and y=g(t) over the interval specified in the second argument. With a list of expressions of two (a(u,v),b(u,v),c(u,v)) and a list of values for the (u=u0...u1,v=v0...v1) as arguments, draws the surface defined by x=a(u,v), y=b(u,v), and z=c(u,v) over the intervals specified by in the second argument.

```
plotparam(Cplx||Lst,Var||Lst(Var))
```

plotpolar For an expression f(x), draws the polar curve r=f(x) for x over the interval VarMin to VarMax.

```
plotpolar(Expr,Var,VarMin,VarMax)
```

plotseq Displays the *p*th terms of the sequence u(0)=a,u(n)=f(u(n–1)).

```
plotseq(Expr(f(Var)),Var=[a,xm,xM],Intg(p))
```

point With a complex as argument, plots it. With the coordinates of a point in three dimensions as argument, plots it.

```
point(Cplx||Vect)
```

polar Returns the line of the conjugated points of A with respect to a circle.

```
polar(Crcle,Pnt or Cplx(A))
```

polar_coordinates Returns the list of the norm and of the argument of the affix of a point, complex number or list of rectangular coordinates.

```
polar_coordinates(Pnt or Cplx or LstRectCoord)
```

polar_point Returns the point with polar coordinates r and t.

```
polar_point(Real(r),Real(t))
```

pole Returns the point for which the line is polar with respect to the circle.

```
pole(Crcle,Line)
```

POLYCOEF Returns the coefficients of a polynomial with roots given in the vector argument.

```
polyCoef(Vect)
```

POLYEVAL Evaluates a polynomial given by its coefficients at x0.

```
polyEval(Vect,Real(x0))
```

polygon Draws the polygon whose vertices are elements in a list.

```
polygon(LstPnt||LstCplx)
```

polygonplot Draws the polygons made by joining the points (xk,yk), where xk=element row k column 0 and yk=element row k column j (for j fixed and for k=0...nrows).

```
polygonplot(Mtrx)
```

polygonscatterplot Draws the points (xk,yk) and the polygons made by joining the points (xk,yk), where xk=element row k column 0 and yk=element row k column j (for j fixed and for k=0...nrows).

```
polygonscatterplot(Mtrx)
```

polyhedron Draws a convex polyhedron whose vertices are the points in the sequence.

```
polyhedron(SeqPnt(A,B,C...))
```

polynomial_regression Returns the coefficients (an,...a1,a0) of y=an*x^n+..a1x+a0), where y is the nth order polynomial which best approximates the points whose coordinates are the elements in two lists or the rows of a matrix.

```
polynomial_regression(Lst||Mtrx(A),[Lst],Intg(n))
```

POLYROOT Returns the zeros of the polynomial given as argument (either as symbolic expression or as a vector of coefficients).

```
POLYROOT(P(x) or Vect)
```

potential Returns a function whose gradient is the vector field defined by Vect(V) and VectVar.

```
potential(Vect(V),VectVar)
```

power_regression Returns the coefficients (m,b) of y=b*x^m, where y is the monomial which best approximates the points whose coordinates are the elements in two lists or the rows of a matrix.

```
power_regression(Lst|Mtrx(A),[Lst])
```

powerpc Returns the real number d^2–R^2, where d is the distance between the point and the center of the circle, and R is the radius of the circle.

```
powerpc(Crcle,Pnt or Cplx)
```

prepend Adds an element to the beginning of a list.

```
prepend(Lst,Elem)
```

primpart Returns a polynomial divided by the greatest common divisor of its coefficients.

```
primpart(Poly,[Var])
```

prism Draws a prism whose base is the plane ABCD and whose edges are parallel to the line made by A and A1.

```
prism(LstPnt([A,B,C,D]),Pnt(A1))
```

product With an expression as the first argument, returns the product of solutions when the variable in the expression is substituted from *a* to *b* with step *p*. If *p* is not provided, it is taken as 1. With a list as the first argument, returns the product of the values in the list. With a matrix as the first argument, returns the element-by-element product of the matrix.

```
product(Expr||Lst,[Var||Lst],[Intg(a)],[Intg(b)],[Intg(p)])
```

projection Returns the orthogonal projection of the point on the curve.

```
projection(Curve,Pnt)
```

propfrac Returns a fraction or rational fraction A/B simplified to Q+r/B, where R<B or the degree of R is less than the degree of B.

```
propfrac(Frac or RatFrac)
```

ptayl Returns the Taylor polynomial Q such as P(x)=Q(x–a).

```
ptayl(Poly(P(var)),Real(a),[Var])
```

purge Unassigns a variable name.

```
purge(Var)
```

pyramid With three points as arguments, draws the pyramid with a face in the plane of the three points and with two vertices at the first and second points. With four points as arguments, draws the pyramid with vertices at the four points.

```
pyramid(Pnt(A),Pnt(B),Pnt(C),[Pnt(D)])
```

q2a Returns the matrix of a quadratic form with respect to the given in VectVar.

```
q2a(QuadraForm,VectVar)
```

quadrilateral Draws the quadrilateral ABCD.

```
quadrilateral(Pnt(A)||Cplx,Pnt(B)||Cplx,Pnt(C
)||Cplx,Pnt(D)||Cplx)
```

quantile Returns the quantile of the elements of a list corresponding to p (0<p<1).

```
quantile(Lst(l),Real(p))
```

quartile1 Returns the first quartile of the elements of a list or the columns of a matrix.

```
quartile1(Lst||Mtrx,[Lst])
```

quartile3 Returns the third quartile of the elements of a list or the columns of a matrix.

```
quartile3(Lst||Mtrx,[Lst])
```

quartiles Returns the minimum, first quartile, median, third quartile, and maximum of the elements of a list or the columns of a matrix.

```
quartiles(Lst||Mtrx,[Lst])
```

quorem Returns the quotient and remainder of the Euclidean division (by decreasing power) of two polynomials. The polynomials can be expressed as vectors of their coefficients or in symbolic form.

```
quorem((Vect or Poly),(Vect or Poly),[Var])
```

QUOTE Returns an expression unevaluated.

```
quote(Expr)
```

radical_axis Returns the line which is the locus of points at which tangents drawn to two circles have the same length.

```
radical_axis(Crcle,Crcle)
```

randexp Returns a random real according to the exponential distribution of parameter a>0.

```
randexp(Real(a))
```

randperm Returns a random permutation of [0,1,2,…,n–1].

```
randperm(Intg(n))
```

ratnormal Rewrites an expression as an irreducible rational fraction.

```
ratnormal(Expr)
```

reciprocation Returns the list where a point is replaced with its polar or a line is replaced with its pole with respect to the circle.

```
reciprocation(Crcle,Lst(Pnt,Line))
```

rectangle Draws the rectangle ABCD, where, if k is provided, AD=k*AB if k>0, and where, if k and P are provided, the rectangle is in the plane ABP with AD=AP and AD=k*AB.

```
rectangle(Pnt(A)||Cplx,Pnt(B)||Cplx,Real(k)||
Pnt(P)||Lst(P,k),[Var(D)],[Var(C)])
```

rectangular_coordinat Returns the list of the abscissas and of the ordinates of points given by a list of their polar coordinates.

```
rectangular_coordinates(LstPolCoord)
```

red Used with `display` to specify the color of the geometrical object to be displayed.

reduced_conic Takes a conic expression and a vector of , and returns the origin of the conic, the matrix of a basis in which the conic is reduced, 0 or 1 (0 if the conic is degenerate), the reduced equation of the conic, and a vector of the conic's parametric equations.

```
reduced_conic(Expr,[LstVar])
```

ref Returns the solution to a system of linear equations written in matrix form.

```
ref(Mtrx(M))
```

reflection With a line (D) and a point (C) as arguments, returns the reflection of the point across the line (i.e. the line is taken as a line of symmetry). With a point (A) and a curve (C) as arguments, returns the reflection of the curve about the point (i.e. the point is taken as the point of symmetry).

```
reflection((Pnt(A) or Line(D)),(Pnt(C) or
Curve(C)))
```

remove Returns a list with the elements that satisfy the Boolean function removed.

```
remove(FncBool(f)||e,Lst(l))
```

reorder Reorders the in an expression according to the order given in LstVar.

```
reorder(Expr,LstVar)
```

REPEAT Used in programming to indicate a statement or statements that should be repeated until a given condition is true.

residue Returns the residue of an expression at *a*.

```
residue(Expr,Var(v),Cplx(a))
```

restart Purges all the .

```
restart(NULL)
```

resultant Returns the resultant (i.e. the determinant of the Sylvester matrix) of two polynomials.

```
resultant(Poly,Poly,Var)
```

RETURN Used in programming return a value of a function at a certain point.

```
return(Expr)
```

revlist Returns a list with the elements in reverse order.

```
revlist(Lst)
```

rhombus With two points (A and B) and an angle (a) as arguments, draws the rhombus ABCD such that the angle AB-AD=a. With three points as arguments (A, B and P), draws the rhombus ABCD in the plane ABP such that angle AB-AD=angle AB-AP.

```
rhombus(Pnt(A)||Cplx,Pnt(B)||Cplx,Angle(a)||P
nt(P)||Lst(P,a)),[Var(C)],[Var(D)])
```

right_triangle With two points (A and B) and a real (k) as arguments, draws right-angled triangle such ABC such that AC=k*AB. With three points (A, B and P) as arguments, draws the right-angled triangle ABC in the plane ABP and such that AC=AP.

```
right_triangle((Pnt(A) or Cplx),(Pnt(B) or
Cplx),(Real(k) or Pnt(P) or
Lst(P,k)),[Var(C)])
```

romberg Uses Romberg's method to return the approximate value of the integral of the expression over the interval *a* to *b*.

```
romberg(Expr(f(x)),Var(x),Real(a),Real(b))
```

rotation With a point (B), an angle (a1) and another point (A) as arguments, returns the result of rotating the second point by the angle about the center of rotation given by the first point. With a line (Dr3), an angle (a1) and a curve as arguments, returns the result of rotating the curve by the angle about the axis of rotation given by the line.

```
rotation((Pnt(B) or Cplx or
Dr3),Angle(a1),(Pnt(A) or Curve))
```

row Returns the row n or the sequence of the rows n1...n2 of the matrix A.

```
row(Mtrx(A),Intg(n)||Interval(n1..n2))
```

rowAdd Returns the matrix obtained from matrix A after the n2th row is replaced by the sum of the n1th row and the n2th row.

```
rowAdd(Mtrx(A),Intg(n1),Intg(n2))
```

rowDim Returns the number of rows of a matrix.

```
rowDim(Mtrx)
```

rowSwap Returns the matrix obtained from matrix A after the n1th row and the n2th row are swapped.

```
rowSwap(Mtrx(A),Intg(n1),Intg(n2))
```

rsolve Returns the values of a recurrent sequence or a system of recurrent sequences.

```
rsolve((Expr or LstExpr),(Var or
LstVar),(InitVal or LstInitVal))
```

segment Draws a line segment connecting two points.

```
segment((Pnt or Cplx),(Pnt or
Cplx),[Var],[Var])
```

select Returns a list with only the elements that satisfy the Boolean function remaining.

```
select(FncBool(f),Lst(l))
```

seq With an expression and two integers (a and b) as arguments, returns the sequence obtained when the expression is evaluated within the interval given by a and b. With an expression and three integers (a, b and p) as arguments, returns the sequence obtained when the expression is evaluated with step of p within the interval given by a and b. With an expression and three integers (n, a and b) as arguments, returns the sequence obtained when the expression is evaluated n times of equal spacing within the interval given by a and b.

```
seq(Expr,Intg(n)||Var(var),[Intg(a)],[Intg(b)
],[Intg(p)])
```

seqsolve Returns the value of a recurrent sequence or a system of recurrent sequences (u_{n+1}=f(u_n) or u_{n+2}=f(u_{n+1},u_n)...).

```
seqsolve((Expr or LstExpr),(Var or
LstVar),(InitVal or LstInitVal))
```

shift_phase Returns the result of applying a phase shift of pi/2 to a trigonometric expression.

```
shift_phase(Expr)
```

signature Returns the signature of a permutation.

```
signature(Permut)
```

similarity With two points (B and A), a real (k) and an angle (a1) as arguments, returns a point that is the point similar to A across center B with angle a1 and with scaling coefficient k. With an axis (Dr3), a real (k) an angle (a1) and a point (A) as arguments, returns a point that is the point similar to A across the axis given by the line with angle a1 and with scaling coefficient k.

```
similarity(Pnt(B) or
Dr3,Real(k),Angle(a1),Pnt(A))
```

simult Returns the solution to a system of linear equations or several systems of linear equations presented in matrix form. In other words, in the case of one system of linear equations, takes a matrix A and a column matrix B, and returns column matrix X such A*X=B.

SIN Sine: sinx.

```
SIN(value)
```

sincos Returns an expression with the complex exponentials rewritten in terms of sin and cos.

```
sincos(Expr)
```

single_inter With two curves or two surfaces as arguments, returns one of the intersections of the two curves or surfaces. With to curves or surfaces and a point or list of points as arguments, returns an intersection of the curves or surfaces that is nearest to the point or not in the list of points.

```
single_inter(Curve,Curve,[Pnt(A)||LstPnt(L)])
```

slopeat Displays the value at point z0 of the slope of the line or segment d. A legend is provided.

```
slopeat(Line,Pnt||Cplx(z0))
```

slopeatraw Displays the value at point z0 of the slope of the line or segment d.

```
slopeatraw(Line, Pnt||Cplx(z0))
```

sphere With two points as arguments, draws the sphere of diameter made by the line from one point to another. With a point and a real as arguments, draws the sphere with center at the point and radius given by the real.

```
sphere((Pnt or Vect),(Pnt or Real))
```

spline Returns the natural spline through the points given by two lists. The polynomials in the spline are in variable x and of degree d.

```
spline(Lst(lx),Lst(ly),Var(x),Intg(d))
```

sqrt Returns the square root of an expression.

```
sqrt(Expr)
```

square Draws the square of side AB in the plane ABP.

```
square((Pnt(A) or Cplx),(Pnt(B) or
Cplx),[Pnt(P),Var(C),Var(D)])
```

stddev Returns the standard deviance of the elements in a list with the second argument as pound or returns the list of standard deviances of the columns of a matrix. What does the “pound” mean?

```
stddev(Lst||Mtrx,[Lst])
```

stddevp Returns the population standard deviance of the elements in a list with the second argument as pound or returns the list of standard deviances of the columns of a matrix. What does the "pound" mean?

```
stddevp(Lst||Mtrx,[Lst])
```

STEP Used in prgramming to indicate the step in an iteration or the step size of an incrementation.

sto Stores a real or string in a variable.

```
sto((Real or Str),Var)
```

sturmseq Returns the Sturm sequence for a polynomial or a rational fraction.

```
sturmseq(Poly,[Var])
```

subMat Extracts from a matrix a sub matrix with first element=A[n1,n2] and last element=A[n3,n4].

```
subMat(Mtrx(A),Intg(n1),Intg(n2),Intg(n3),Int
g(n4))
```

suppress Returns a list without the nth element.

```
suppress(Lst,Intg(n))
```

surd Returns an expression to the power of 1/n.

```
surd(Expr,Intg(n))
```

sylvester Returns the Sylvester matrix of two polynomials.

```
sylvester(Poly,Poly,Var)
```

table Defines an array where the indexes are strings or real numbers.

```
table(SeqEqual(index_name=element_value))
```

tail Returns a list or sequence or string without its first element.

```
tail(Lst or Seq or Str)
```

TAN Tangent: tan(*x*).

```
tan(value)
```

tan2cossin2 Returns an expression with tan(x) rewritten as (1–cos(2*x))/sin(2*x).

```
tan2cossin2(Expr)
```

tan2sincos2 Returns an expression with tan(x) rewritten as sin(2*x)/(1+cos(2*x)).

```
tan2sincos2(Expr)
```

tangent With a curve as argument, draws the tangent line to the curve at point A. With a surface as argument, draws the tangent plane to the surface at point A.

```
tangent(Curve or surface(C),Pnt(A))
```

THEN Used in programming to introduce a statement dependent on a conditional statement.

TO Used in programming in a loop when expressing the range of values of a variable for which a statement should be executed.

translation With a vector and a point as arguments, returns the point translated by the vector. with two points as arguments, returns the second point translated by the vector from the origin to the first point.

```
translation(Vect,Pnt(C))
```

transpose Returns a matrix transposed (without conjugation).

```
transpose(Mtrx)
```

triangle Draws a triangle with vertices at the three points.

```
triangle((Pnt or Cplx),(Pnt or Cplx),(Pnt or
Cplx))
```

trunc Returns a value or a list of values truncated to n decimal places. If n is not provided, it is taken as 0. Accepts complex numbers.

```
trunc(Real||LstReal,Int(n))
```

tsimplify Returns an expression with transcendentals rewritten as complex exponentials.

```
tsimplify(Expr)
```

type Returns the type of an expression (e.g. list, string).

```
type(Expr)
```

UFACTOR Factorizes a unit in a unit object.

```
ufactor(Unit,Unit)
```

unapply Returns the function defined by an expression and a variable.

```
unapply(Expr,Var)
```

UNTIL Used in programming to indicate the conditions under which a statement should stop being executed.

USIMPLIFY Simplifies a unit in a unit object.

```
usimplify(Unit)
```

valuation Returns the valuation (degree of the term of lowest degree) of a polynomial. With only a polynomial as argument, the valuation returned is for *x*. With a variable as second argument, the valuation is performed for it.

```
valuation(Poly,[Var])
```

variance Returns the variance of a list with the second argument as pound or the list of variances of the columns of a matrix.

```
variance(Lst||Mtrx,[Lst])
```

vector With one point as argument, defines a vector from the origin to the point. With two points as arguments, defines a vector from the first point to the second point. With a point and a vector as arguments, defines a vector beginning from the point and with direction and magnitude of the vector.

```
vector(Pnt,Pnt||Pnt,Vect).
```

vertices Returns the list of the vertices of a polygon or polyhedron.

```
vertices(Polygon or Polyedr)
```

vertices_abca Returns the closed list [A,B,...A] of the vertices of a polygon or polyhedron.

```
vertices_abca(Polygon or Polyedr)
```

vpotential Returns U such as curl(U)=V.

```
vpotential(Vect(V),LstVar)
```

when Used to introduce a conditional statement.

WHILE Used to indicate the conditions under which a statement should be executed.

XOR Exclusive or. Returns 1 if the first expression is true and the second expression is false or if the first expression is false and the second expression is true. Returns 0 otherwise.

```
xor(Expr1,Expr2)
```

yellow Used with `display` to specify the color of the geometrical object to be displayed.

zip Applies a bivariate function to the elements of two lists. Without the default value its length is the minimum of the lengths of the two lists and the shorter list is padded with the default value.

`zip(Fnc2d(f),Lst(l1),Lst(l2),[Val(default)])`

| Substitutes a value for a variable in an expression.

`|(Expr,Var(v1)=value(a1)[,v2=a2,...])`

^{2} Returns the square of an expression.

`(Expr)`^{2}

π Inserts pi.

10^ What does this one do?

∂ Inserts a template for a partial derivative expression.

Σ Inserts a template for a summation expression.

– Inserts a minus sign.

$\sqrt{}$ Inserts a square root sign.

$\int$ Inserts a template for an antiderivative expression.

$\neq$ Inserts a not-equal-to sign.

$\leq$ Inserts a less-than-or-equal-to sign.

$\geq$ Inserts a greater-than-or-equal-to sign.

▶ Evaluates the expression then stores the result in variable var. Note that ▶ cannot be used with the graphics G0–G9. See the command `BLIT`.

`expression` ▶ `var`

i Inserts the imaginary number *i*.

$^{-1}$ Returns the inverse of an expression.

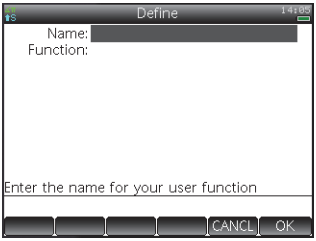
`(Expr)`$^{-1}$

Creating your own functions

You can create your own function by writing a program (see chapter 26) or by using the simpler `DEFINE` functionality. Functions you create yourself appear on the User menu (one of the Toolbox menus).

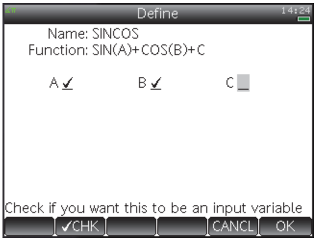
Suppose you wanted to create the function SINCOS(A,B)=SIN(A)+COS(B)+C.

1. Press Shift xtθn (Define).



2. In the **Name** field, enter a name for the function—for example, SINCOS—and tap OK.
3. In the **Function** field, enter the function.

   SIN ALPHA A ▶ + COS ALPHA B ▶ ALPHA C OK



   New fields appear below your function, one for each potential parameter it. will take. You need to decide which ones are to be parameters when the function is called. In this example, we'll make A and B parameters. The value of C will be provided by global variable C (which by default is zero).

4. Make sure that `A` and `B` are selected and `C` is not.
5. Tap OK.

   You can run your function by entering it on the entry line in Home view, or be selecting it from the USER menu. You enter the value for each variable you chose to be a parameter. In this example. we chose A and B to be parameters. Thus you might enter SINCOS(0.5, 0.75).

Variables

Variables are placeholders for objects (such as function definitions, numbers, matrices, the results of calculations, and the like). Some are built-in and cannot be deleted. But you can also create your own.

Many built-in variables are automatically assigned objects as a result of some operation (such as defining a polar function, performing a calculation, or setting an option). For example, if you define a polar function, that definition is assigned to variable named R_0 to R_n. If you use the Function app to find the slope of a curve at some *x*-value, the slope is assigned to a variable named `Slope`. And if you choose *binary* as the base for integer arithmetic, a built-in variable named `Base` is given the value 0. If you had chosen octal instead, `Base` would have been given the value 1.

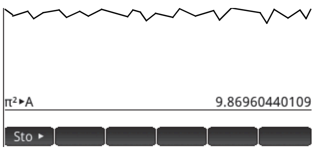
Creating variables

Variables you create are assigned whatever value you give them. You can assign a value to certain built-in variables (such as the Home variables). You can also create your own variables. Example 1 below gives an example of assigning a value to a built-in variable, and example 2 illustrates how to create a variable and assign a value to it

Example 1: To assign π^2 to the built-in variable *A*:

Shift 3 x^2 Sto ► ALPHA Vars Enter

Your stored value appears as shown at the right. If you then wanted to multiply your stored value by 5, you could enter:



ALPHA Vars × 5 Enter

To assign an object to a built-in variable, it is important that you choose a variable that matches the type of object. For example, you cannot assign a complex number to the variables A through Z. These are reserved fro real numbers. Complex numbers need to be assigned to variables Z0 through Z9. Likewise, matrices can only be assigned to the built-in variables M0 through M9. See "Home variables" on page 377 for more information.

You can also take advantage of the built-in variables in CAS view. However, the built-in CAS variables must be entered in lowercase: *a*–*z*.

Example 2: You can create your own variables—in Home view and in CAS view. For example, suppose you want to create a variable called `ME` and assign π^2 to it. You would enter:

Shift 3 x² Sto ▸ ALPHA +/− ALPHA a b/c Enter

A message appears asking if you want to create a variable called ME. Tap OK or press Enter to confirm your intention. You can now use that variable in subsequent calculations: `ME*3` will yield 303, for example.

You can also create variables by entering [variable name]:=[object]. For example, entering ALPHA 1 ALPHA , ALPHA 4 ALPHA − Shift ÷ 55 Enter assigns 55 to the variable YOU. You can now use that variable in subsequent calculations: YOU+60 will yield 115, for example.

Using variables to change settings

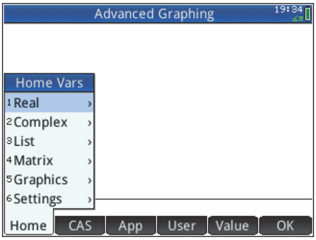
Just as you can assign values to variables you create yourself, you can assign values to certain built-in variables. You could modify Home settings on the **Home Settings** screen (Shift Settings). But you can also modify a Home setting from Home view by assigning a value to the variable that represents that setting. For example, entering 0 Sto ▸ `Base` Enter in Home view forces the setting for the integer base to binary. (A value of 1 would force it to octal, 2 to decimal, and 3 to hex.) Another example: you can change the angle measure setting from radians to degrees by entering 1 Sto ▸ `HAngle` Enter in Home view. Entering 0 Sto ▸ `HAngle` Enter forces the setting to return to radians.

[What are the allowable attributes for the other settings?]

Retrieving variables

You can see what value has been assigned to a variable—built-in or user-defined—by entering its name in Home view and pressing Enter. You can enter the name letter by letter, or choose the variable from the Variables menu.

The Variables menu is opened by tapping Vars. There are four sub-menus, covering Home, CAS, app, and user variables. Home variables are the built-in variables set by what you do in Home view or by the settings you choose on the **Home Settings** screen. Some examples are `HAngle` and `Base`. App variables are also built-in, but they are set by what you do in an app. Some examples are `XMax` and `Slope`. The CAS variables and user variables are those you create yourself.

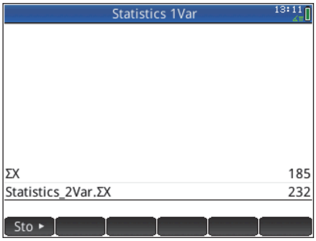


If you want to retrieve just the value of a variable and not its name, tap Value before you select the variable from a Variables menu.

Qualifying variables

Some variables are common to more than one app. For example, the Function app has a variable named `Xmin`, but so too does the Polar app, the Parametric app, the Sequence app, and the Solve app. Likewise, the ΣX variable is common to both the Statistics 1Var and Statistics 2Var apps. Although named identically, these variables can hold different values.

If you attempt to retrieve a variable that is used in more than one app by entering just its name in Home view, you will get the value that was *last* calculated for that variable. This might not be the value that you want. To ensure you get the right value, you need to qualify the variable with the name of the app that generated it. In the example at the right, the variable ΣX was entered, but it returned the value of that variable as it was calculated in the Statistics 1Var app (the first entry). However, it was the value of the variable as it was calculated in the Statistics 2Var app that was sought. To retrieve that value, the variable name had to be qualified by prefixing it with the name of the app that generated it: `Statistics_2Var` followed by a period (the second entry).



Note the syntax required:

```
app_name.variable_name
```

Spaces are not allowed in an app name and must be represented by the underscore character: Shift _. The app can be a built-in app or one you have crated based on a built-in app. The name of a built-in variable must match a name listed in the Home variables or App variables tables below.

Tip Non-standard characters in variables name—such as Σ and σ—can be entered by selecting them from the special symbols palette: Shift 9.

Home variables

The Home variables are accessed by pressing Vars Chars A and tapping Home.

Category	Available names
Real	A to Z and θ For example, 7.45 Sto ▸ A
Complex	Z0 to Z9 For example, 2+3×*i* Sto ▸ Z1 or (2,3) Sto ▸ Z1 (depending on your Complex number settings)
List	L0 to L9 For example, {1,2,3} Sto ▸ L1.
Matrix	M0 to M9 Store matrices and vectors in these variables. For example, [[1,2],[3,4]] Sto ▸ M1.
Graphics	G0 to G9
Settings	HAngle HFormat HDigits HComplex Date Time Language Entry Integer Base Bits Signed

App variables

The app variables are accessed by pressing Vars and tapping App. They are grouped below by app. (You can find then grouped by view—Symbolic, Numeric, Plot, —in "Variables and Programs" on page 492.)

Note that if you have customized a built-in app, your app will appear on the App variables menu under the name you gave it. You access the variables in a customized app in the same way that you access the variables in built-in apps.

Function app variables

Category	Names	
Results[a]	Area Extremum Isect	Root Slope

Symbolic	`F1`
	`F2`
	`F3`
	`F4`
	`F5`
		`F6`
		`F7`
		`F8`
		`F9`
		`F0`

Plot	`Axes`
	`Cursor`
	`GridDots`
	`GridLines`
	`Labels`
	`Method`
	`Recenter`
	`Xmax`
		`Xmin`
		`Xtick`
		`Xzoom`
		`Ymax`
		`Ymin`
		`Ytick`
		`Yzoom`

Numeric	`NumStart`
	`NumStep`
	`Automatic`
	`NumIndep`
		`NumType`
		`NumZoom`
		`BuildYourOwn`

Modes	`AAngle` `AComplex`	`ADigits` `AFormat`

a. The Results variables contain the last value found by the Signed Area, Extremum, Intersection, Root, and Slope functions respectively.

Geometry app variables

Category	Names	
Numeric	XMin YMin	XMax
Modes	AAngle AComplex	ADigits AFormat

Spreadsheet app variables

Category	Names	
Numeric	ColWidth Row Cell	RowHeight Col
Modes	AAngle AComplex	ADigits AFormat

Advanced Graphing app variables

Category	Names	
Symbolic	S1 S2 S3 S4 S5	S6 S7 S8 S9 S0
Plot	Axes Cursor GridDots GridLines Labels Method Recenter Xmax	Xmin Xtick Xzoom Ymax Ymin Ytick Yzoom
Numeric	NumXStart NumYStart NumXStep NumYStep NumIndep	NumType NumXZoom NumYZoom Automatic BuildYourOwn
Modes	AAngle AComplex	ADigits AFormat

Solve app variables

Category	Names	
Symbolic	E1 E2 E3 E4 E5	E6 E7 E8 E9 E0
Plot	Axes Cursor GridDots GridLines Labels Method Recenter Xmax	Xmin Xtick Xzoom Ymax Ymin Ytick Yzoom

Category	Names (Continued)	
Modes	AAngle AComplex	ADigits AFormat

Statistics 1Var app variables

Category	Names	
Results [explained below]	NbItem Min Q1 Med Q3 Max	ΣX ΣX2 MeanX sX σX serrX
Symbolic	H1 H2 H3 H4 H5	H1Type H2Type H3Type H4Type H5Type
Plot	Axes Cursor GridDots GridLines Hmin Hmax Hwidth Labels Recenter	Xmax Xmin Xtick Xzoom Ymax Ymin Ytick Yzoom
Numeric	D1 D2 D3 D4 D5	D6 D7 D8 D9 D0
Modes	AAngle AComplex	ADigits AFormat

Results

NbItem Contains the number of data points in the current 1-variable analysis (H1–H5).

Min Contains the minimum value of the data set in the current 1-variable analysis (H1–H5).

Q1 Contains the value of the first quartile in the current 1-variable analysis (H1–H5).

Med Contains the median in the current 1-variable analysis (H1–H5).

Q3 Contains the value of the third quartile in the current 1-variable analysis (H1–H5).

Max Contains the maximum value in the current 1-variable analysis (H1–H5).

ΣX Contains the sum of the data set in the current 1-variable analysis (H1–H5).

ΣX2 Contains the sum of the squares of the data set in the current 1-variable analysis (H1–H5).

MeanX Contains the mean of the data set in the current 1-variable analysis (H1–H5).

sX Contains the sample standard deviation of the data set in the current 1-variable analysis (H1–H5).

σX Contains the population standard deviation of the data set in the current 1-variable analysis (H1–H5).

serrX Contains the standard error of the data set in the current 1-variable analysis (H1–H5).

Statistics 2Var app variables

Category	Names	
Results [explained below]	NbItem Corr CoefDet sCov σCov ΣXY MeanX ΣX ΣX2	sX σX serrX MeanY ΣY ΣY2 sY σY serrY

Symbolic	`S1`
	`S2`
	`S3`
	`S4`
	`S5`
		`S1Type`
		`S2Type`
		`S3Type`
		`S4Type`
		`S5Type`

Plot	`Axes`
	`Cursor`
	`GridDots`
	`GridLines`
	`Labels`
	`Method`
	`Recenter`
	`Xmax`
		`Xmin`
		`Xtick`
		`Xzoom`
		`Ymax`
		`Ymin`
		`Ytick`
		`Yzoom`

Numeric	`C1`
	`C2`
	`C3`
	`C4`
	`C5`
		`C6`
		`C7`
		`C8`
		`C9`
		`C0`

Modes	`AAngle` `AComplex`	`ADigits` `AFormat`

Results

NbItem

Contains the number of data points in the current 2-variable analysis (`S1-S5`).

Corr Contains the correlation coefficient from the latest calculation of summary statistics. This value is based on the linear fit only, regardless of the fit type chosen.

CoefDet Contains the coefficient of determination from the latest calculation of summary statistics. This value is based on the fit type chosen.

sCov Contains the sample covariance of the current 2-variable statistical analysis (`S1–S5`).

σCov Contains the population covariance of the current 2-variable statistical analysis (`S1–S5`).

ΣXY Contains the sum of the X·Y products for the current 2-variable statistical analysis (`S1–S5`).

MeanX Contains the mean of the independent values (X) of the current 2-variable statistical analysis (`S1–S5`).

ΣX Contains the sum of the independent values (X) of the current 2-variable statistical analysis (`S1–S5`).

ΣX2 Contains the sum of the squares of the independent values (X) of the current 2-variable statistical analysis (`S1–S5`).

sX Contains the sample standard deviation of the independent values (X) of the current 2-variable statistical analysis (`S1–S5`).

σX Contains the population standard deviation of the independent values (X) of the current 2-variable statistical analysis (`S1–S5`).

serrX Contains the standard error of the independent values (X) of the current 2-variable statistical analysis (`S1–S5`).

MeanY Contains the mean of the dependent values (Y) of the current 2-variable statistical analysis (`S1–S5`).

ΣY Contains the sum of the dependent values (Y) of the current 2-variable statistical analysis (`S1–S5`).

ΣY2 Contains the sum of the squares of the dependent values (Y) of the current 2-variable statistical analysis (`S1–S5`).

sY Contains the sample standard deviation of the dependent values (Y) of the current 2-variable statistical analysis (`S1–S5`).

σY Contains the population standard deviation of the dependent values (Y) of the current 2-variable statistical analysis (`S1–S5`).

serrY Contains the standard error of the dependent values (Y) of the current 2-variable statistical analysis (`S1–S5`).

Inference app variables

Category	Names	
Results [explained below]	Result TestScore TestValue Prob	CritScore CritVal1 CritVal2 DF
Symbolic	AltHyp Method	Type
Numeric	Alpha Conf Mean1 Mean2 n1 n2 μ0 π0	Pooled s1 s2 σ1 σ2 x1 x2
Modes	`AAngle` `AComplex`	`ADigits` `AFormat`

Results

CritScore Contains the value of the Z- or t-distribution associated with the input α-value

CritVal1 Contains the lower critical value of the experimental variable associated with the negative `TestScore` value which was calculated from the input α-level.

CritVal2 Contains the upper critical value of the experimental variable associated with the positive `TestScore` value which was calculated from the input α-level.

DF Contains the degrees of freedom for the t-tests.

Prob Contains the probability associated with the `TestScore` value.

Result For hypothesis tests, contains 0 or 1 to indicate rejection or failure to reject the null hypothesis.

TestScore Contains the Z- or t-distribution value calculated from the hypothesis test or confidence interval inputs.

TestValue Contains the value of the experimental variable associated with the `TestScore`.

Parametric app variables

Category	Names	
Symbolic	X1 Y1 X2 Y2 X3 Y3 X4 Y4 X5 Y5	X6 Y6 X7 Y7 X8 Y8 X9 Y9 X0 Y0
Plot	Axes Cursor GridDots GridLines Labels Method Recenter Tmin Tmax	Tstep Xmax Xmin Xtick Xzoom Ymax Ymin Ytick Yzoom
Numeric	Automatic BuildYourOwn NumIndep NumStart	NumStep NumType NumZoom
Modes	AAngle AComplex	ADigits AFormat

Polar app variables

Category	Names	
Symbolic	R1 R2 R3 R4 R5	R6 R7 R8 R9 R0

Category	Names (Continued)	
Plot	θmin	Recenter
	θmax	Xmax
	θstep	Xmin
	Axes	Xtick
	Cursor	Xzoom
	GridDots	Ymax
	GridLines	Ymin
	Labels	Ytick
	Method	Yzoom
Numeric	Automatic	NumStep
	BuildYourOwn	NumType
	NumIndep	NumZoom
	NumStart	
Modes	AAngle	ADigits
	AComplex	AFormat

Finance app variables

Category	Names	
Numeric	CPYR	NbPmt
	BEG	PMTV
	FV	PPYR
	IPYR	PV
Modes	AAngle	ADigits
	AComplex	AFormat

Linear Solver app variables

Category	Names	
Numeric	LSystem	LSolution[a]
Modes	AAngle	ADigits
	AComplex	AFormat

a. Contains a vector with the last solution found by either the Linear Solver app or the LSolve app function.

Triangle Solver app variables

Category	Names	
Numeric	SideA SideB SideC Rect	AngleA AngleB AngleC
Modes	`AAngle` `AComplex`	`ADigits` `AFormat`

Linear Explorer app variables

Category	Names	
Modes	`AAngle` `AComplex`	`ADigits` `AFormat`

Quadratic Explorer app variables

Category	Names	
Modes	`AAngle` `AComplex`	`ADigits` `AFormat`

Trig Explorer app variables

Category	Names	
Modes	`AAngle` `AComplex`	`ADigits` `AFormat`

Sequence app variables

Category	Names	
Symbolic	U1 U2 U3 U4 U5	U6 U7 U8 U9 U0
Plot	Axes Cursor GridDots GridLines Labels Nmin Nmax Recenter	Xmax Xmin Xtick Xzoom Ymax Ymin Ytick Yzoom
Numeric	Automatic BuildYourOwn NumIndep NumStart	NumStep NumType NumZoom
Modes	AAngle AComplex	ADigits AFormat

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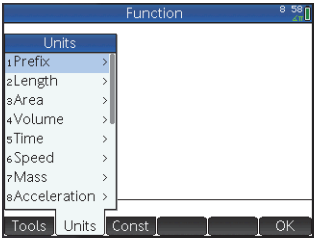
Units and constants

Units

A unit of measurement—such as inch, ohm, or Becquerel—enables you give a precise magnitude to a physical quantity.

You can attach a unit of measurement to any number or numerical result. A numerical value with units attached is referred to as a *measurement*. You can operate on measurements just as you do on numbers without attached units. The units are kept with the numbers in subsequent operations.

The units are on the **Units** menu. Press Shift (Units) and, if necessary, tap Units.



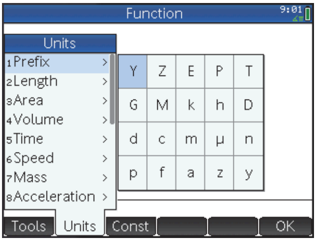
The menu is organized by *category*. Each category is listed at the left, with the units in the selected category listed at the right.

Unit categories

- length
- area
- volume
- time
- speed
- mass
- acceleration
- force
- energy
- power
- pressure
- temperature
- electricity
- light
- angle
- viscosity
- radiation

Prefixes

The **Units** menu includes an entry that is not a unit category, namely, `Prefix`. Selecting this option displays a palette of prefixes.



Y: yotta	Z: zetta	E: exa	P: peta	T: tera
G: giga	M: mega	k: kilo	h: hecto	D: deca
d: deci	c: centi	m: milli	μ: micro	n: nano
p: pico	f: femto	a: atto	z: zepto	y: octo

Unit prefixes provide a handy way of entering large or small numbers. For example, the speed of light is approximately 300,000 m/s. If you wanted to use that in a calculation, you could enter it as 300_km/s, with the prefix *k* selected from the prefix palette.

Select the prefix you want *before* selecting the unit.

Unit calculations

A number plus a unit is a measurement. You can perform calculations with multiple measurements providing that the units of each measurement are from the same category. For example, you can add two measurements of length (even lengths of different units, as illustrated in the following example). But you cannot add, say, a length measurement to a volume measurement.

Example

Suppose you want to add 20 centimeters and 5 inches and have the result displayed in centimeters.

1. If you want the result in cm, enter the centimeter measurement first.

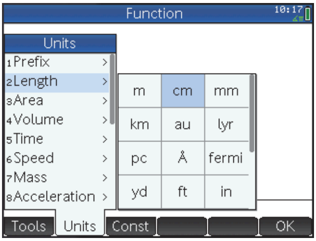
   20 Shift Units (Units)

   Units

   Select Length

   ▶

   Select cm



2. Now add 5 inches.

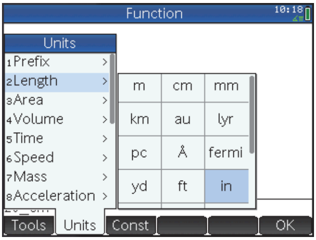
   + 5 Shift Units

   Select Length

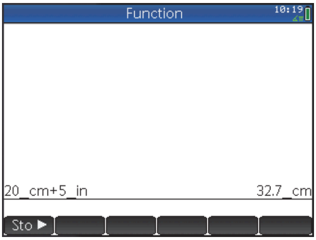
   ▶

   Select in

   Enter



   The result is shown as 32.7 cm. If you had wanted the result in inches, then you would have entered the 5 inches first.



3. To continue the example, let's divide the result by 4 seconds.

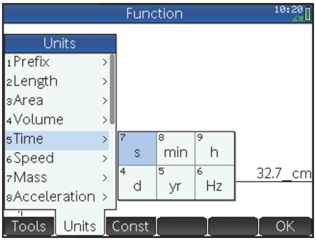
   ÷ 4 Shift Units

   Select Time

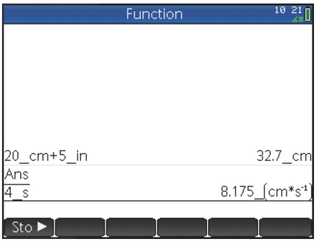
   ▶

   Select s

   Enter



   The result is shown as 8.175 cm*s^{-1}.



4. Now convert the result to kilometers per hour.

   Shift Units Tools

   Select CONVERT

   Select `8.175_(cm/s)` in History.

   Copy , 1

   Shift Units Units

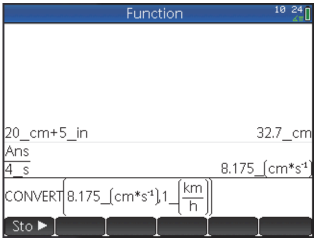
   Select Speed

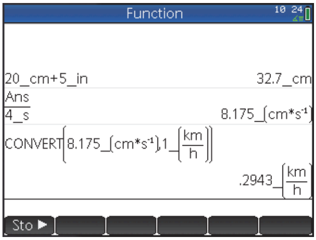
   ▶

   Select km/h

   Enter

   The result is shown as 0.2943 kilometers per hour.





Unit tools

There are a number of tools for managing and operating on units. These are available by pressing Shift Units and tapping Tools.

CONVERT

Converts one unit to another unit of the same category.

`CONVERT(5_m,1_ft)` returns `16.4041994751_ft`

You can also use the last answer as the first argument in a new conversion calculation. Pressing Shift Ans places the last answer on the entry line. You can also select a value from history and tap Copy to copy it to the entry line.

MKSA

Meters, kilograms, seconds, amperes. Converts a complex unit into the base components of the MKSA system.

`MKSA(8.175_cm/s)` returns `.08175_m*s-1`

UFACTOR

Unit factor conversion. Converts a measurement using a compound unit into a measurement expressed in constituent units. For example, a Coulomb—a measure of electric charge—is a compound unit derived from the SI base units of Ampere and second: 1 C = 1 A * 1 s. Thus:

`UFACTOR(100_C,1_A))` returns `100 A*s`

USIMPLIFY

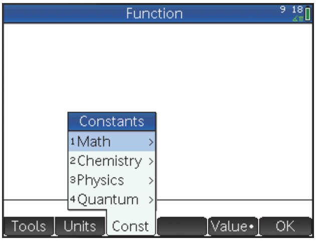
Unit simplification. For example, a Joule is defined as one kg*m^2/s^2. Thus:

`USIMPLIFY(5_kg*m2/s2)` returns `5_J`

Physical constants

The values of 34 math and physical constants can be selected by name and used in calculations. These constants are grouped into four categories: math, chemistry, physics and quantum mechanics. A list of all these constants is given in "List of constants" on page 396.

To display the constants, press Shift Units and then tap Const:

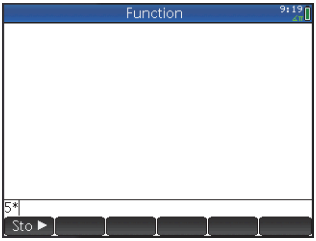


Example

Suppose you want to know the potential energy of a mass of 5 units according to the equation $E = mc^2$.

1. Enter the mass and the multiplication operator:

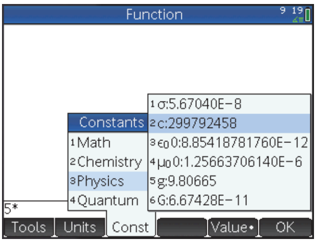
   5 ×



2. Open the constants menu.

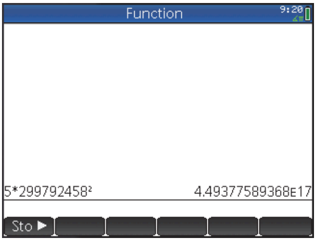
   Shift Units Const

3. Select `Physics`.
4. Select `c: 299792458`.



5. Square the speed of light and evaluate the expression.

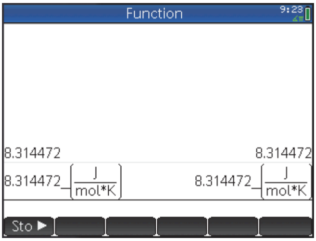
x² Enter



Value or measurement?

You can enter just the value of a constant or the constant and its units (if it has units). If Value• is showing on the screen, the value is inserted at the cursor point. If Value is showing on the screen, the value and its units are inserted at the cursor point.

In the example at the right, the first entry shows the Universal Gas Constant after it was chosen with Value• showing. The second entry shows the same constant, but chosen when Value was showing.



Tapping Value displays Value•, and vice versa.

List of constants

Category	**Name and symbol**
Math	e MAXREAL MINREAL π i
Chemistry	`Avogadro` NA Boltmann, k molar volume, Vm universal gas, R standard temperature, StdT standard pressure, StdP

Category	Name and symbol (Continued)
Phyics	Stefan-Boltzmann, σ speed of light, c permittivity, ε_0) permeability, μ_0 acceleration of gravity, g gravitation, G
Quantum	Planck, h Dirac, $\hbar$ electronic charge, q electron mass, me q/me ratio, qme proton mass, mp mp/me ratio, mpme fine structure, α magnetic flux, Φ Faraday, F Rydberg, R_∞ Bohr radius, a_0 Bohr magneton, μ_B nuclear magneton, μ_N photon wavelength, λ_0 photon frequency, f_0 Compton wavelength, λ_c

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Lists

A list consists of comma-separated real or complex numbers, expressions, or matrices, all enclosed in braces. A list may, for example, contain a sequence of real numbers such as `{1,2,3}`. Lists represent a convenient way to group related objects.

You can do list operations in Home and in programs.

There are ten list variables available, named `L0` to `L9`. You can use them in calculations or expressions in Home or in a program. Retrieve a list name from the Vars menu (Vars), or just type its name from the keyboard.

You can create, edit, delete, send, and receive named lists in the List Catalog: Shift 7 (List). You can also create and store lists—named or unnnamed—in Home view.

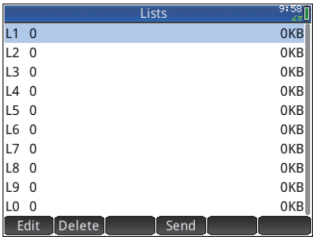
List variables are identical in behavior to the columns `C1-C0` in the Statistics 2Var app and the columns `D1-D0` in the Statistics 1Var app. You can store a statistics column as a list (or vice versa) and use any of the list functions on the statistics columns, or the statistics functions on the list variables.

Create a list in the List Catalog

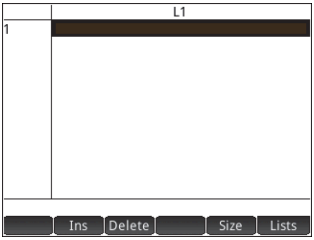
1. Open the List Catalog.

   Shift 7 (List)

   The number of elements in a list is shown beside the list name.



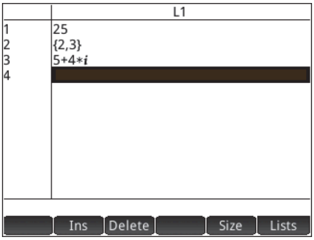
2. Tap on the name you want to assign to the new list (`L1`, `L2`, etc.). The list editor appears.



   If you're creating a new list rather than changing, make sure you choose a list with out any elements in it.

3. Enter the values you want in the list, pressing Enter after each one.

   Values can be real or complex numbers (or an expression). If you enter a expression, it is evaluated and the result is inserted in the list.



4. When done, press Shift 7 (List) to return to the List catalog, or press Settings to go to Home view.

List Catalog: Buttons and keys

The buttons and keys in the List Catalog are:

Button or Key	Purpose
Edit	Opens the highlighted list for editing. You can also just tap on a list name.
Delete or Del	Deletes the contents of the selected list.
Send	Transmits the highlighted list to another HP Prime.
Shift Esc (Clear)	Clears all lists.
Shift ▲ or ▼	Moves to the end or the beginning of the catalog.

The List Editor

The List Editor is a special environment for entering data into lists. There are two ways to open the List Editor once the List Catalog is open:

- Highlight the list and tap Edit or
- Tap the name of the list.

List Editor: Buttons and keys

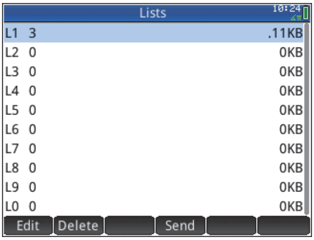
When you open a list, the following buttons and keys are available to you:

Button or Key	Purpose
Edit	Copies the highlighted list item into the entry line.
Ins	Inserts a new value—with default zero—before the highlighted item.
Delete or Del	Deletes the highlighted item.
Size	Displays a menu for you to choose the small font, medium font, or large font
Lists	Displays a menu for you to choose how many lists to display at one time: one, two, three, or four. For example, if you have only `L4` displayed and you choose `3` from the **Lists** menu, lists `L5` and `L6` will be displayed in addition to `L4.`
Shift Esc Clear (Clear)	Clears all items from the list.
Shift ▲ or ▼	Moves the cursor to the start or the end of the list.

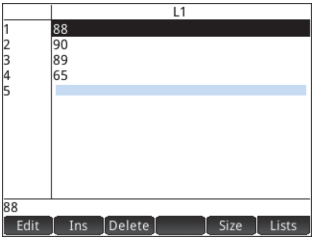
To edit a list

1. Open the List Catalog.

   Shift 7 (List)

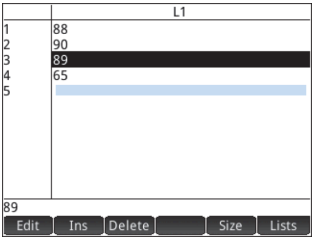


2. Tap on the name of the list (`L1`, `L1`,etc.). The List Editor appears.



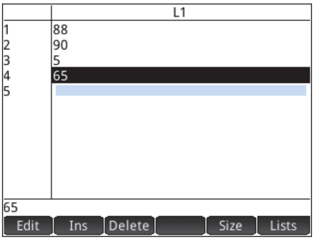
3. Tap on the element you want to edit. (Alternatively, press ▲ or ▼ until the element you want to edit is highlighted.) In this example, edit the third element so that it has a value of 5.

   5 OK



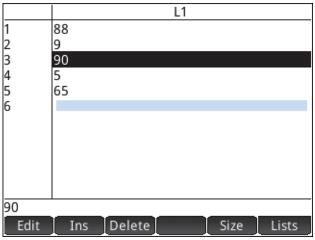
To insert an element in a list

Suppose you want to insert a new value, 9, in L1(2) in the list L1 shown to the right.



Select L1(2), that is, the second element in the list.

Ins 9 OK



Deleting lists

To delete a list

In the List Catalog, use the cursor keys to highlight the list and press Del. You are prompted to confirm your decision. Tap OK or press Enter.

Only the contents of the list is deleted. The list is simply stripped of its contents.

To delete all lists

In the List Catalog, press Shift Esc (Clear).

Only the contents of each list is deleted. The lists are simply stripped of their contents.

Lists in Home view

You can enter and operate on lists directly in Home view. The lists can be named or unnamed.

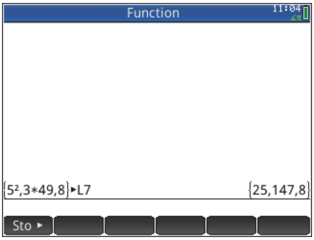
To enter a list

1. Press Shift 8 ({}).
   A pair of braces appears on the entry line. All lists must be enclosed in braces.
2. Enter the first element in the list followed by a comma:
   [element] ,
3. Continue adding elements, separating each with a comma.
4. When you have finished entering the elements, press Enter. The list is added to History (with any expressions among the elements evaluated).

To store a list

You can store a list in a variable. You can do this before the list is added to History, or you can copy it from History. When you've entered a list in the entry line or copied it from History to the entry line, tap **Sto ▸**, enter a name for the list and press Enter. The list variable names available to you are `L0` through `L9`.

For example, to store the list {25,147,8} in `L7`:



1. Create the list on the entry line.
2. Press ▶ to move the cursor outside the list.
3. Tap **Sto ▸**.
4. Enter the name:

   ALPHA x^2 7

5. Complete the operation: Enter.

To display a list

To display a list in Home view, type its name and press Enter.

If the list is empty, a pair of empty braces is returned.

To display one element

To display one element of a list in Home view, enter *listname* (*element#*). For example, if L6 is {3,4,5,6}, then `L6(2)` Enter returns `4`.

To store one element

To store a value in one element of a list in Home view, enter *value* **Sto ▸** *listname* (*element#*). For example, to store 148 as the second element in L2, type `148` **Sto ▸** `L2(2)` Enter.

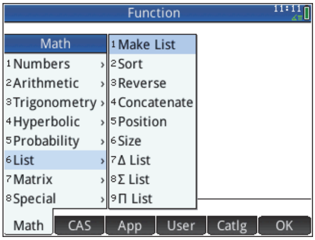
To send a list

You can send lists to another calculator or a PC just as you can apps, programs, matrices, and notes. See "Sharing data" on page 40 for instructions.

List functions

List functions are found on the Math menu. You can use them in Home and 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 Mem 6 to select the *List* category in the left column of the Math menu. (*List* is the sixth category on the Math menu, which is why pressing 6 will take you straight to the List category.) Press ▶ to move to the sub-menu of list functions, select a function, and either tap OK or press Enter.

List functions are enclosed in parentheses. They have arguments that and separated by commas, as in `CONCAT(L1,L2)`. An argument can be either a list variable name (such as L1) or the actual list. For example, `REVERSE({1,2,3})`.

Common operators like +, –, ×, and ÷ can take lists as arguments. If there are two arguments and both are lists, then the lists must have the same length, since the calculation pairs the elements. If there are two arguments and one is a real number, then the calculation operates on each element of the list.

Example:

`5*{1,2,3}` returns `{5,10,15}`.

Besides the common operators that can take numbers, matrices, or lists as arguments, there are commands that can only operate on lists.

Menu format

By default, a List function is presented on the Math menu using its descriptive name, not its common command name. Thus the shorthand name `CONCAT` is presented as **Concatenate** and `POS` is presented as **Position**.

If you prefer the Math menu to show command names instead, deselect the **Menu Display** option on page 2 of the **Home Settings** screen (see page 26).

Make List

Calculates a sequence of elements for a new list using the syntax:

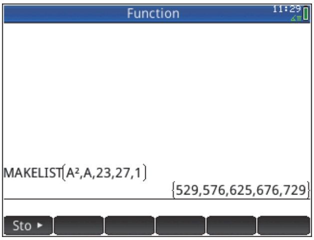
`MAKELIST(`*expression, variable, begin, end, increment*`)`

Evaluates *expression* with respect to *variable*, as *variable* takes on values from *begin* to *end* values, taken at *increment* steps.

Example:

In Home, generate a series of squares from 23 to 27:

[Mem B] 6 1
[ALPHA] [Vars] [x²] [,]
[ALPHA] [Vars] [,]
23 [,]
27 [,] 1 [Enter]



Sort

Sorts the elements in a list in ascending order.

`SORT(`*list*`)`

Example:

`SORT({2,5,3})` returns `{2,3,5}`

Reverse

Creates a list by reversing the order of the elements in a list.

`REVERSE(`*list*`)`

Example:

`REVERSE({1,2,3})` returns `{3,2,1}`

Concatenate

Concatenates two lists into a new list.

`CONCAT(`*list1, list2*`)`

Example:

`CONCAT({1,2,3},{4})` returns `{1,2,3,4}`.

Position

Returns the position of an element within a list. The *element* can be a value, a variable, or an expression. If there is more than one instance of the element, the position of the first occurrence is returned. A value of 0 is returned if there is no occurrence of the specified element.

`POS(`*list, element*`)`

Example:

`POS ({3,7,12,19},12)` returns `3`

Size

Returns the number of elements in a list.

`SIZE(`*list*`)`

Example:

`SIZE({1,2,3})` returns `3`

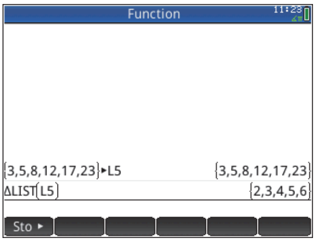
ΔLIST

Creates a new list composed of the first differences, that is, the differences between consecutive elements in a list. The new list has one less element than the original list. The differences for $\{x_1, x_2, x_3,... x_{n-1}, x_n\}$ are $\{x_2-x_1, x_3-x_2,... x_n-x_{n-1}\}$.

`ΔLIST(`*list1*`)`

Example:

In Home view, store {3,5,8,12,17,23} in L5 and find the first differences for the list.



Shift 8

3,5,8,12,17,23

▶ Sto ▸

ALPHA x² 5 Enter

Mem 6 7 ALPHA x² 5 Enter

ΣLIST

Calculates the sum of all elements in a list.

`ΣLIST(`*list*`)`

Example:

`ΣLIST({2,3,4})` returns `9`.

ΠLIST

Calculates the product of all elements in list.

`ΠLIST(`*list*`)`

Example:

`ΠLIST({2,3,4})` returns `24`.

Finding statistical values for lists

To find statistical values—such as the mean, median, maximum, and minimum of a list—you create a list, store it in a data set and then use the Statistics 1Var app.

Example

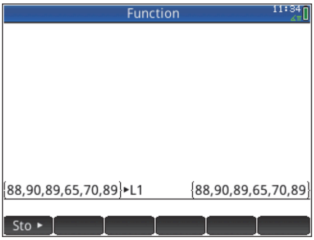
In this example, use the Statistics 1Var app to find the mean, median, maximum, and minimum values of the elements in the list L1, being 88, 90, 89, 65, 70, and 89.

1. In Home view, create L1.

   Shift 8

   88, 90, 89, 65, 70,89 ▶ Sto ▸

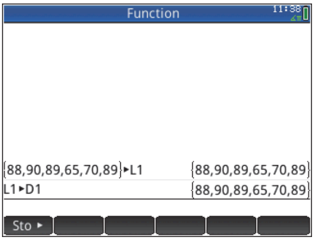
   ALPHA x^2 1 Enter



2. In Home view, store L1 in D1.

   ALPHA x^2 1 Sto ▸

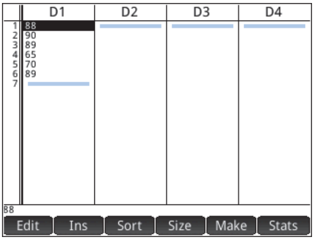
   ALPHA $x\,t\,\theta\,n$ 1 Enter



   You will now be able to see the list data in the Numeric view of the Statistics 1Var app.

3. Start the Statistics 1Var app.

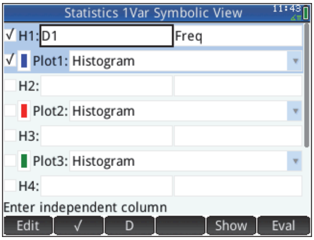
   Apps Info Select `Statistics 1Var`

   Notice that your list elements are in data set D1.

4. In the Symbolic view, specify the data set whose statistics you want to find.

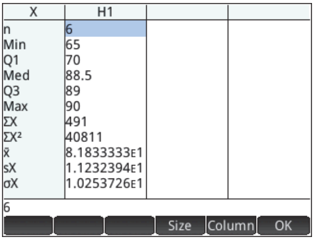
   Symb Setup

   By default, H1 will use the data in D1, so nothing further needs to be done in Symbolic view. However, if the data of interest were in D2, or any column other than D1, you would have to specify the desired data column here.

5. Calculate the statistics.

   Num Setup Stats

6. Tap OK when you are done.

   See the chapter 9, "Statistics 1Var app", beginning on page 187, for the meaning of each statistic.

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Matrices

You can perform matrix calculations in Home view and in programs. The matrix and each row of a matrix appear in square brackets, and the elements and rows are separated by commas. For example, the following matrix:

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

is displayed in History as:

`[[1,2,3],[4,5,6]]`

You can enter matrices directly on the entry line, or create them in the Matrix Editor.

Vectors

Vectors are one-dimensional arrays. They are composed of just one row. A vector is represented by single brackets; for example, [1,2,3]. A vector can be a real number vector, or a complex number vector such as [(1,2), (7,3)].

Matrices

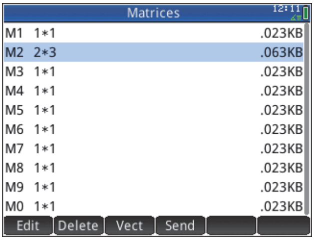
Matrices are two-dimensional arrays. They are composed of at least two rows and at least one column. Two-dimensional matrices are represented by nested brackets; for example, [[1,2,3],[4,5,6]]. You can also create complex matrices, for example, [[(1,2), (3,4)], [(4,5), (6,7)]].

Matrix Variables

There are ten matrix variables available, named `M0` to `M9`. You can use them in calculations in Home view or in a program. You can retrieve matrix names from the Vars menu, or just type their names from the keyboard.

Creating and storing matrices

The Matrix Catalog contains the matrix variables `M0–M9`. Once you select a matrix name, you can create, edit, and delete matrices in the Matrix Editor. You can also send a matrix to another HP Prime.



To open the Matrix Catalog, press Shift 4 (Matrix).

In the Matrix Catalog, the size of a matrix is shown beside the matrix name. (An empty matrix is shown as `1*1`.) The number of elements in it is shown beside a vector.

You can also create and store matrices—named or unnamed—in Home view. For example, the command:

```
POLYROOT([1,0,-1,0])▶M1
```

stores the roots of the complex vector of length 3 into the variable M1. M1 will thus contain the three roots of $x^3 - x = 0$: 0, 1 and –1.

Matrix Catalog: buttons and keys

The buttons and keys available in the Matrix Catalog are:

Button or Key	Purpose
Edit	Opens the highlighted matrix for editing.
Delete or Del	Deletes the content sof the selected matrix.
Vect	Changes the selected matrix into a one-dimensional vector.
Send	Transmits the highlighted matrix to another HP Prime.
Shift Esc (Clear)	Clears the contents of all matrices.

Working with matrices

To open the Matrix Editor

To create or edit a matrix, go to the Matrix Catalog, and tap on a matrix. (You could also use the cursor keys to highlight the matrix and then press Edit.) The Matrix Editor opens.

Matrix Editor: Buttons and keys

The buttons and keys available in the Matrix Editor are.:

Button or Key	Purpose
Edit	Copies the highlighted element to the entry line.
Ins	Inserts a row of zeros above, or a column of zeros to the left, of the highlighted cell. You are prompted to choose row or column.
Size	Displays a menu for you to choose the small font, medium font, or large font.
Go	A three-way toggle that controls how the cursor will move after an element has been entered. Go → moves the cursor to the right, Go ↓ moves it downward, and Go does not move it at all.
Column	Displays a menu for you to choose 1, 2, 3, or 4 columns to be displayed at a time.
Del	Replaces the contents of the highlighted cell with a zero.
Shift Esc Clear (Clear)	Deletes the highlighted row, or column, or the entire matrix. (You are prompted to make a choice.)
Shift ▲ ▼ ◀ ▶	Moves the cursor to the first row, last row, first column, or last column respectively.

To create a matrix in the Matrix Editor

1. Open the Matrix Catalog:

   Shift 4 (Matrix)

2. If you want to create a vector, press ▲ or ▼ until the matrix you want to use is highlighted, tap Vect, and then press Enter. Continue from step 4 below.

3. If you want to create a matrix, either tap on the name of the matrix (M0–M9), or press ▲ or ▼ until the matrix you want to use is highlighted and then press Enter.

   Note that an empty matrix will be shown with a size of `1*1` beside its name.

4. For each element in the matrix, type a number or an expression, and then tap OK or press Enter.

   You can enter **complex numbers** in complex form, that is, (a, b), where a is the real part and b is the imaginary part. You can also enter them in the form $a+bi$.

5. By default, on entering an element the cursor moves to the next column in the same row. You can use the cursor keys to move to a different row or column. You can also change the direction the cursor automatically moves by tapping Go. The Go button toggles between the following options:

   – Go ↓: the cursor moves to the cell below the current cell when you press Enter.

   – Go →: the cursor moves to the cell to the right of the current cell when you press Enter.

   – Go: the cursor stays in the current cell when you press Enter.

6. When done, press Shift 4 (Matrix) to return to the Matrix Catalog, or press Settings to return to Home view. The matrix entries are automatically saved.

Matrices in Home view

You can enter and operate on matrices directly in Home view. The matrices can be named or unnamed.

1. Enter the vector or matrix on the entry line. The vector or matrix must be enclosed in square brackets. Start

each row of a matrix with square brackets as well. (For a pair of square brackets, press Shift 5.)

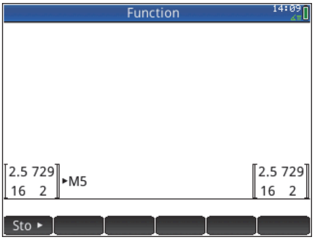
Separate each element and each row with a comma (,).

2. When you have finished entering the elements, press Enter. The vector or matrix is added to History (with any expressions among the elements evaluated).
3. Press Enter to evaluate and display the vector or matrix.

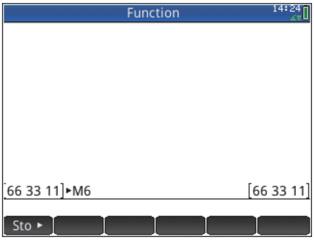
To store a matrix

You can store it a vector or matrix in a variable. You can do this before it is added to History, or you can copy it from History. When you've entered a vector or matrix in the entry line or copied it from History to the entry line, tap Sto ▸, enter a name for it and press Enter. The vector and matrix names variable names available to you are `M0` through `M9`.

The screen at the left shows the matrix `[[2.5,729],[16,2]]` being stored in M5. Note that you can enter an expression (like 5/2) for an element of the matrix, and it will be evaluated.



The screen at the right shows the vector `[66,33,11]` being stored in M6.



To display a matrix

In Home view, enter the name of the vector or matrix and press Enter. If the vector or matrix is empty, zero is returned inside double square brackets.

To display one element

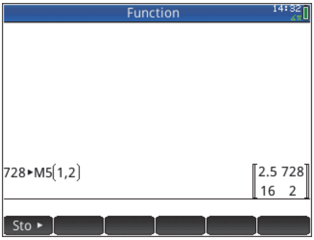
In Home view, enter *matrixname*(*row,column*). For example, if `M2` is `[[3,4],[5,6]]`, then `M2(1,2)` Enter returns `4`.

To store one element

In Home view, enter *value*, tap Sto ▸, and then enter *matrixname*(*row, column*).

For example, to change the element in the first row and second column of M5 to 728 and then display the resulting matrix:

728
Sto ▸ ALPHA +/− 5
( ) 1 , 2
Enter



An attempt to store an element to a row or column beyond the size of the matrix results in re-sizing the matrix to allow the storage. Any intermediate cells will be filled with zeroes.

To send a matrix

You can send matrices between calculators just as you can send apps, programs, lists, and notes. See “Sharing data” on page 40 for instructions.

Matrix arithmetic

You can use the arithmetic functions (+, –, ×, ÷, and powers) with matrix arguments. Division left-multiplies by the inverse of the divisor. You can enter the matrices themselves or enter the names of stored matrix variables. The matrices can be real or complex.

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

Example

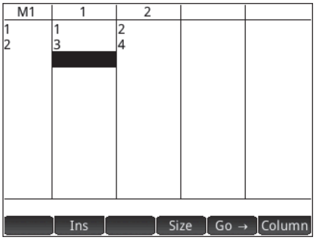
1. Select the first matrix:

   Shift 4 (Matrix)

   Tap M1 or highlight it and press Enter.

2. Enter the matrix elements:

   Go → 1 Enter 2 Enter 3 Enter 4 Enter

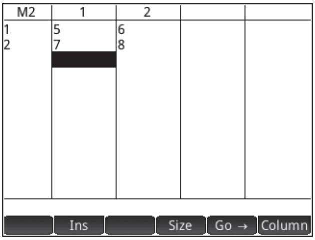


3. Select the second matrix:

   Shift 4 (Matrix)
   Tap M2 or highlight it and press Enter.

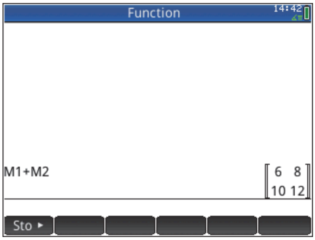
4. Enter the matrix elements:

   5 Enter 6 Enter 7 Enter 8 Enter



5. In Home view, add the two matrices you have just created.

   Home ALPHA +/– 1 + ALPHA +/– 2 Enter

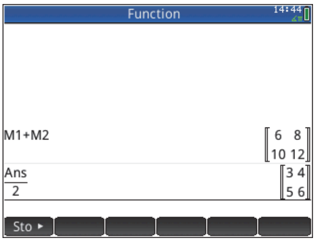


To multiply and divide by a scalar

For division by a scalar, enter the matrix first, then the operator, then the scalar. For multiplication, the order of the operands does not matter.

The matrix and the scalar can be real or complex. For example, to divide the result of the previous example by 2, press the following keys:

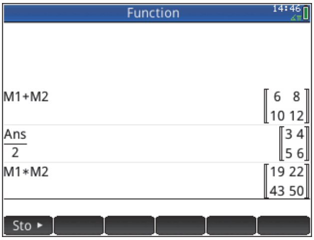
÷ 2 Enter



To multiply two matrices

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

ALPHA +/– 1 × ALPHA +/– 2 Enter

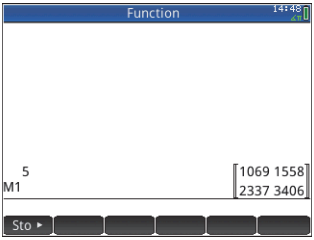


To multiply a matrix by a vector, enter the matrix first, then the vector. The number of elements in the vector must equal the number of columns in the matrix.

To raise a matrix to a power

You can raise a matrix to any power as long as the power is an integer. The following example shows the result of raising matrix M1, created earlier, to the power of 5.

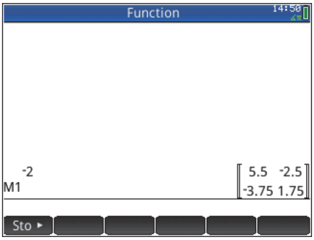
ALPHA +/– 1 x^y 5 Enter



You can also raise a matrix to a power without first storing it as a variable.

Matrices can also be raised to negative powers. In this case, the result is equivalent to 1/[matrix]^ABS(power). In the following example, M1 is raised to the power of –2.

ALPHA +/– 1 x^y +/– 2 Enter



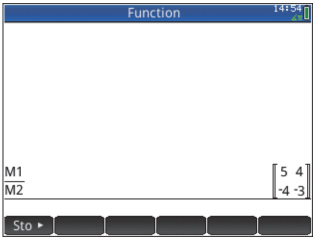
To divide by a square matrix

For division of a matrix or a vector by a square matrix, the number of rows of the dividend (or the number of elements, if it is a vector) must equal the number of rows in the divisor.

This operation is not a mathematical division: it is a left-multiplication by the inverse of the divisor. M1/M2 is equivalent to $M2^{-1} * M1$.

To divide the two matrices you created for the previous example, press the following keys:

ALPHA +/− 1 ÷
ALPHA +/− 2



To invert a matrix

You can invert a *square matrix* in Home view by typing the matrix (or its variable name) and pressing Shift ÷ Enter. You can also use the `INVERSE` command in the Matrix category of the Math menu.

To negate each element

You can change the sign of each element in a matrix by pressing +/−, entering the matrix name, and pressing Enter.

Solving systems of linear equations

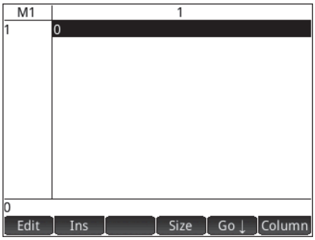
You can use matrices to solve systems of linear equations, such as the following:

$$2x+3y+4z=5$$
$$x+y-z=7$$
$$4x-y+2z=1$$

In this example we will use matrices M1 and M2, but you could use any of the ten matrices available.

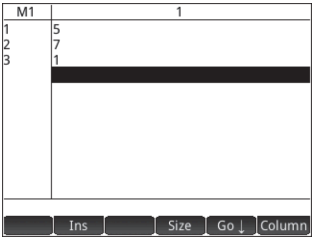
1. Open the Matrix Catalog, clear M1, choose to create a vector, and open the Matrix Editor:

   Shift 4 [select M1] Del OK Vect Enter



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

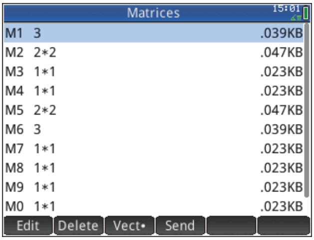
   5 Enter 7 Enter 1 Enter



3. Return to the Matrix Catalog.

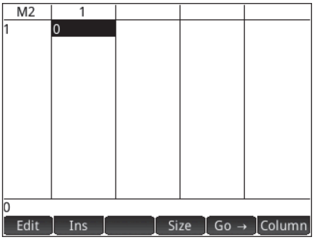
   Shift 4 (Matrix)

   The size of M1 should be showing as 3.



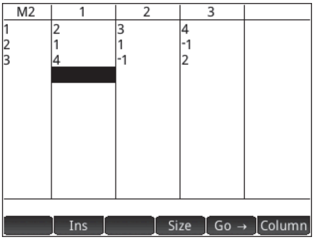
4. Select and clear M2, and re-open the Matrix Editor:

   [Press ▼ or ▲ to select M2] Del OK Enter



5. Enter the equation coefficients.

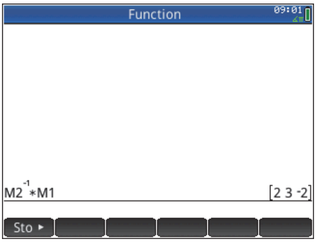
   2 Enter 3 Enter [Tap in cell R1, C3.] 4 Enter 1 Enter 1 Enter +/- 1 Enter 4 Enter +/- 1 Enter 2 Enter



6. Return to Home view and left-multiply the constants vector by the inverse of the coefficients matrix:

   Settings ALPHA +/- 2 Shift ÷ × ALPHA +/- 1 Enter

The result is a vector of the solutions: $x = 2$, $y = 3$ and $z = -2$.



An alternative method is to use the RREF function (see page 422).

Matrix functions and commands

Functions

- Functions can be used in any app or in Home view. They are listed on the Math menu under the Matrix category. They can be used in mathematical expressions—primarily in Home view—as well as in programs.
- Functions always produce and display a result. They do not change any stored variables, such as a matrix variable.
- Functions have arguments that are enclosed in parentheses and separated by commas; for example, `CROSS`(*vector1*,*vector2*). The matrix input can be either a matrix variable name (such as `M1`) or the actual matrix data inside brackets. For example, `CROSS(M1,[1,2])`.

Menu format

By default, a Matrix function is presented on the Math menu using its descriptive name, not its common command name. Thus the shorthand name `TRN` is presented as **Transpose** and `DET` is presented as **Determinant**.

If you prefer the Math menu to show command names instead, deselect the **Menu Display** option on page 2 of the **Home Settings** screen (see page 26).

Commands

Functions differ from commands in that a function can be used in an expression. Commands cannot be used in an expression.

Matrix commands are listed among the functions and commands in the commands catalog, one of the Toolbox menus. Press [Mem B] and tap Catlg to display the commands catalog.

Argument conventions

- For *row#* or *column#*, supply the number of the row (counting from the top, starting with 1) or the number of the column (counting from the left, starting with 1).

- The argument *matrix* can refer to either a vector or a matrix.

Matrix functions

The matrix functions are available in the Matrix category on the Math menu: Select Matrix Select a function.

Transpose Transposes *matrix*. For a complex matrix, TRN finds the conjugate transpose.

`TRN`(*matrix*)

Determinant Determinant of a square *matrix*.

`DET`(*matrix*)

RREF Reduced Row-Echelon Form. Changes a rectangular *matrix* to its reduced row-echelon form.

`RREF`(*matrix*)

Create

Make 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. You can also create a vector by the number of elements (e) instead of the number of rows and columns.

`MAKEMAT`(*expression, rows, columns*)

`MAKEMAT`(*expression, elements*)

Examples

`MAKEMAT(0,3,3)` returns a 3 × 3 zero matrix, `[[0,0,0],[0,0,0],[0,0,0]]`.

`MAKEMAT(√2,2,3)` returns the 2 × 3 matrix `[[√2,√2,√2],[√2,√2,√2]]`.

`MAKEMAT(I+J–1,2,3)` returns the 2 × 3 matrix

`[[1,2,3],[2,3,4]]`

Note in the example above that each element is the sum of the row number and column number minus 1.

`MAKEMAT(√2,2)` returns the 2-element vector `[√2,√2]`.

Identity Identity matrix. Creates a square matrix of dimension *size* × *size* whose diagonal elements are 1 and off-diagonal elements are zero.

`IDENMAT(`*size*`)`

Random Returns a list of size *n* or a *n x m* matrix that contains random integers in the range –99 through 99 with uniform distribution or that contains random numbers according to the law put between `quote`.

```
randMat(Intg(n), [Intg(m)],[Interval
or quote(DistribLaw)])
```

JordanBlock Returns a matrix *n x n* with a on the diagonal, 1 above and 0 everywhere else.

```
JordanBlock(Expr(a),Intg(n))
```

Hilbert Returns the order *n* Hilbert matrix: Hjk=1/(j+k+1) j,k=1...n.

```
hilbert(Intg(n))
```

Isometric Matrix of an isometry given by its proper elements.

```
mkisom(Vect,(Sign(1) or -1))
```

Vandermonde Returns the Vandermonde matrix=[V^0,V^1,...].

```
vandermonde(Vect(V))
```

Basic

Norm Finds the norm of a matrix.

```
ABS(matrix)
```

Row Norm Row Norm. Finds the maximum value (over all rows) for the sums of the absolute values of all elements in a row.

`ROWNORM(`*matrix*`)`

Column Norm Column Norm. Finds the maximum value (over all columns) of the sums of the absolute values of all elements in a column.

`COLNORM(`*matrix*`)`

Spectral Norm Spectral Norm of *matrix*.

`SPECNORM(`*matrix*`)`

Spectral Radius Spectral Radius of a square *matrix*.

`SPECRAD(`*matrix*`)`

Condition Condition Number. Finds the 1-norm (column norm) of a square *matrix*.

`COND(`*matrix*`)`

Rank Rank of a rectangular *matrix*.

`RANK(`*matrix*`)`

Pivot Performs one step of the Gauss-Jordan reduction method on an *n* x *m* matrix A using the element A[nl,nc] (0≤nl≤n and 0≤nc≤m) as pivot, and returns an equivalent matrix with zeros in all elements in column nc except that in row nl.

`pivot(Mtrx(A),Intg(nl),Intg(nc))`

Trace Finds the trace of a square *matrix*. The trace is equal to the sum of the diagonal elements. (It is also equal to the sum of the eigenvalues.)

`TRACE(`*matrix*`)`

Advanced

Eigenvalues Displays the eigenvalues in vector form for *matrix*.

`EIGENVAL(`*matrix*`)`

Eigenvectors Eigenvectors and eigenvalues for a square *matrix*. Displays a list of two arrays. The first contains the eigenvectors and the second contains the eigenvalues.

`EIGENVV(`*matrix*`)`

Jordan Returns the list made by the matrix of passage and the Jordan form of a matrix.

`jordan(Mtrx)`

Diagonal Returns either the diagonal matrix with diagonal l or the diagonal of A.

`diag(Lst(l)||Mtrx(A))`

Cholesky For a numerical symmetric matrix A, returns L matrix such that A=L*tran(L).

`cholesky(Mtrx)`

Hermite Hermite normal form of a matrix with coefficients in Z: returns U,B such that U is invertible in Z, B is upper triangular and B=U*A.

`ihermite(Mtrx(A))`

Hessenberg Matrix reduction to Hessenberg form. Returns [P,B] such that B=inv(P)*A*P.

`hessenberg(Mtrx(A))`

Smith Smith normal form of a matrix with coefficients in Z: returns U,B,V such that U and V invertible in Z, B is diagonal, B[i,i] divides B[i+1,i+1], and B=U*A*V.

`ismith(Mtrx(A))`

Factorize

LQ LQ Factorization. Factorizes a *m × n matrix* into three matrices L, Q, and P, where {[L[*m × n lowertrapezoidal*]],[Q[*n × n orthogonal*]], [P[*m × m permutation*]]}and P*A=L*Q.

`LQ(`*`matrix`*`)`

LSQ Least Squares. Displays the minimum norm least squares matrix (or vector) corresponding to the system *matrix1**X=*matrix2*.

`LSQ`(*matrix1, matrix2*)

LU LU Decomposition. Factorizes a square *matrix* into three matrices L, U, and P, where
{[L[*lowertriangular*]],[U[*uppertriangular*]],[P[*permutation*]]
}}
and P*A=L*U.

`LU`(*matrix*)

QR QR Factorization. Factorizes an *m*×*n* matrix A numerically as Q*R, where Q is an orthogonal matrix and R is an upper triangular matrix, and returns R. R is stored in var2 and Q=A*inv(R) is stored in var1.

`QR`(*matrix A,var1,var2*)

SCHUR Schur Decomposition. Factorizes a square *matrix* into two matrices. If *matrix* is real, then the result is {[[*orthogonal*]],[[*upper-quasi triangular*]]}.
If *matrix* is complex, then the result is {[[*unitary*]],[[*upper-triangular*]]}.

`SCHUR`(*matrix*)

SVD Singular Value Decomposition. Factorizes an $m \times n$ *matrix* into two matrices and a vector:
{[[$m \times m$ *square orthogonal*]],[[$n \times n$ *square orthogonal*]], [*real*]}.

`SVD`(*matrix*)

SVL Singular Values. Returns a vector containing the singular values of *matrix.*

`SVL`(*matrix*)

Vector

Cross Product Cross Product of *vector1* with *vector2*.

`CROSS`(*vector1*, *vector2*)

Dot Product Dot Product of two arrays, matrix1 and matrix2.

`DOT`(matrix1, matrix2)

L^2 Norm Returns the l^2 norm (sqrt(x1^2+x2^2+...xn^2)) of a vector.

`l2norm(Vect)`

L^1 Norm Returns the l^1 norm (sum of the absolute values of the coordinates) of a vector.

`l1norm(Vect)`

Max Norm Returns the l^∞ norm (the maximum of the absolute values of the coordinates) of a vector.

`maxnorm(Vect or Mtrx)`

Examples

Identity Matrix

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

You can also create an identity matrix using the `MAKEMAT` (*make matrix*) function. For example, entering `MAKEMAT`(I ≠ J,4,4) creates a 4 × 4 matrix showing the numeral 1 for all elements except zeros on the diagonal. The logical operator (≠) returns 0 when I (the row number) and J (the column number) are equal, and returns 1 when they are not equal. (You can insert ≠ by choosing it from the relations palette: Shift 6.)

Transposing a Matrix

The `TRN` function swaps the row–column and column–row elements of a matrix. For instance, element 1,2 (row 1, column 2) is swapped with element 2,1; element 2,3 is swapped with element 3,2; and so on.

For example, `TRN([[1,2],[3,4]])` creates the matrix `[[1,3],[2,4]]`.

Reduced-Row Echelon Form

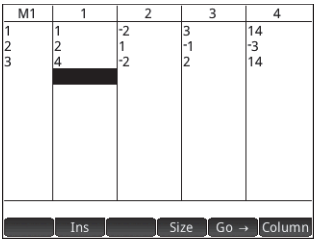
The set of equations

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

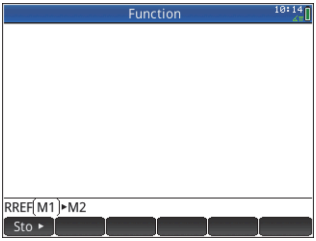
can be written as the augmented matrix

$$\left[\begin{array}{ccc|c} 1 & -2 & 3 & 14 \\ 2 & 1 & -1 & -3 \\ 4 & -2 & 2 & 14 \end{array}\right]$$

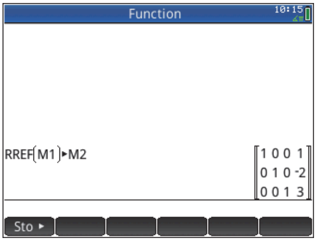
which can then be stored as a 3×4 real matrix in any matrix variable. M1 is used in this example.



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



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

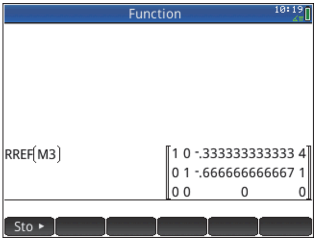


An advantage of using the `RREF` function is that it will also work with inconsistent matrices resulting from systems of equations which have no solution or infinite solutions.

For example, the following set of equations has an infinite number of solutions:

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

The final row of zeros in the reduced-row echelon form of the augmented matrix indicates an inconsistent system with infinite solutions.



25

Notes and Info

The HP Prime has two text editors for entering notes:

- The Note Editor: opens from within the Note Catalog (which is a collection of notes independent of apps).
- The Info Editor: opens from the Info view of an app. A note created in the Info view is associated with the app and stays with it if you send the app to another calculator.

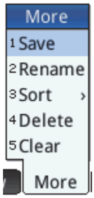
The Note Catalog

Subject to available memory, you can store as many notes as you want in the Note Catalog. These notes are independent of any app. The Note Catalog lists the notes by name. This list excludes notes that were created in any app's Info view, but these can be copied and then pasted into the Note Catalog via the clipboard. From the Note Catalog, you create or edit individual notes in the Note Editor.

Note Catalog: button and keys

While you are in the Note Catalog, you can use the following buttons and keys. Note that some buttons will not be available if there are no notes in the Note Catalog.

Button or Key	Purpose
Edit	Opens the selected note for editing.
New	Begins a new note, and prompts you for a name.
More	Tap to provide additional features. See below.

Button or Key	Purpose (Continued)
	Save creates a copy of the selected note and prompts you to save it under a new name. Rename renames the selected note. Sort sorts the list of notes (sort options are alphabetical and chronological). Delete deletes the selected note. Clear deletes all notes.
Del	Deletes the selected note.
Shift Esc Clear	Deletes all notes in the catalog.
Send	Sends the selected note to another HP Prime or PC.

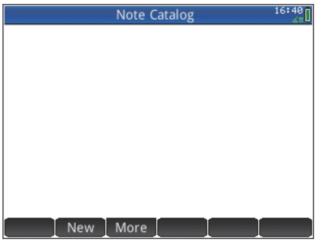
The Note Editor

The Note Editor is where you create and edit notes. You can launch the Note Editor from the Notes Catalog, and also from within an app. Notes created within an app stay with that app even if you send the app to another calculator. Such notes do not appear in the Notes Catalog. They can only be read when the associated app is open. Notes created via the Notes Catalog are not specific to any app and can be viewed at any time by opening the Notes Catalog. Such notes can also be sent to another calculator.

To create a note from the Notes Catalog

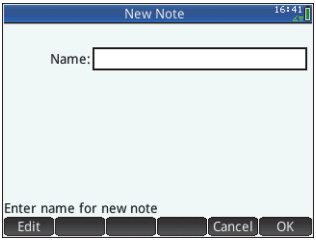
1. Open the Note Catalog.

   Shift 0 Notes



2. Create a new note.

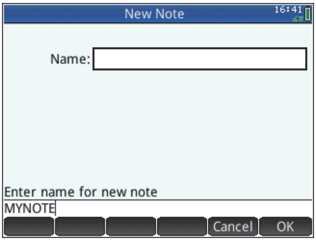
   New



3. Enter a name for your note. In this example, we'll call the note MYNOTE.

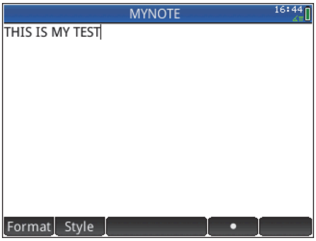
   ALPHA ALPHA MYNOTE

   OK OK



4. Write your note, using the editing keys and formatting options described in the following sections.

   When you are finished, exit the Note Editor by pressing Settings or pressing Apps Info and opening an app. Your work is automatically saved.



   To access your new note, return to the Notes Catalog.

To create a note for an app

You can also create a note that is specific to an app and which stays with the app should you send the app to another calculator. See "Adding a note to an app" on page 96. Notes created this way take advantage of all the formatting features of the Note Editor (see below).

Note Editor: buttons and keys

The following buttons and keys are available while you are adding or editing a note.

Button or Key	Purpose
Format	Opens the text formatting menu. See “Formatting Options” on page 434.
Style	Provides bold, italic, underline, full caps, superscript and subscript options. See “Formatting Options” on page 434
•	A toggle button that offers three types of bullet. See “Formatting Options” on page 434
	Provides options for inserting formulas
␣	Enters a space during text entry.
▲ Page ▼	Moves from page to page in a multi-page note.
Shift View Copy	Shows options for copying text in a note. See below.
Begin	Copy option. Mark where to begin a text selection.
End	Copy option. Mark where to end a text selection.
All	Copy option. Select the entire note.
Cut	Copy option. Cut the selected text.
Copy	Copy option. Copy the selected text.
Del	Deletes the character to the left of the cursor.
Enter ≈	Starts a new line.
Shift Esc Clear (Clear)	Erases the entire note.
Vars Chars A	Menu for entering variable names, and the contents of variables.

Button or Key	Purpose (Continued)
Toolbox (Mem B)	Menu for entering math commands.
Shift Vars (Chars)	Displays a palette of special characters. To type one, highlight it and tap OK or press Enter. To copy a character *without* closing the Chars menu, select it and tap Echo.

Entering uppercase and lowercase characters

The following table below describes how to quickly enter uppercase and lowercase characters.

Purpose	Keys
Make the next character upper-case	ALPHA
Lock mode: make all characters uppercase until the mode is reset	ALPHA ALPHA
With uppercase locked, make next character lowercase	Shift
With uppercase locked, make all characters lowercase until the mode is reset	Shift ALPHA
Reset uppercase lock mode	ALPHA
Make the next character lower-case	ALPHA Shift
Lock mode: make all characters lowercase until the mode is reset	ALPHA Shift ALPHA
With lowercase locked, make next character uppercase	Shift
With lowercase locked, make all characters uppercase until the mode is reset	Shift ALPHA
Reset lowercase lock mode	ALPHA ALPHA ALPHA ALPHA

The left side of the notification area of the title bar will indicate what case will be applied to the character you next enter.

Text formatting

You can enter text in different formats in the Note Editor. Choose a formatting option before you start entering text. The formatting options are described in “Formatting Options” below.

Formatting Options

Formatting options are available from three touch buttons in the Note Editor and in the Info view of an app:

Format Style •

The formatting options are listed in the table below.

Category	Options
Format Font Size	• 10–22 pt
Format Foreground Color	Select from twenty colors.
Format Background Color	Select from twenty colors.
Format Align (text alignment)	• Left • Center • Right
Style Font Style	• Bold • Italic • Underline • Strikethrough • Superscript • Subscript
• Bullets	• • • ◦ • ▹ • × [Cancels bullet]

To import a note

You can import a note from the Note Catalog into an app's Info view and vice versa.

Suppose you want to copy a note named *Assignments* from the Note Catalog into the Function Info view:

1. Open the Note Catalog.

   Shift 0 Notes

2. Select the note `Assignments` and tap Edit
3. Open the copy options for copying to the clipboard.

   Shift View Copy (Copy)

   The menu buttons change to give you options for copying:

   Begin: Marks where the copying or cutting is to begin.

   End: Marks where the copying or cutting is to end.

   All: Select the entire program.

   Cut: Cut the selection.

   Copy: Copy the selection.

4. Select what you want to copy or cut (using the options listed immediately above).
5. Tap Copy or Cut.
6. Open the Info view of the Function app.

   Apps Info, tap the Function app icon, press Shift Apps Info.

7. Move the cursor to the location where you want the copied text to be pasted and open the clipboard.

   Shift Menu Paste

8. Select the text from the clipboard and press OK.

Sharing notes

You can send a note to another HP Prime. See "Sharing data" on page 40.

26

Programming

This chapter describes how to program the HP Prime. In this chapter you'll learn about:

- programming commands
- writing functions in programs
- using variables in programs
- executing programs
- debugging programs
- creating programs for building custom apps
- sending a program to another HP Prime

HP Prime Programs

An HP Prime program contains a sequence of commands that execute automatically to perform a task.

Command Structure

Commands are separated by a semicolon (;). Commands that take multiple arguments have those arguments enclosed in parentheses and separated by a comma(,). For example,

`PIXON` (*xposition*, *yposition*);

Sometimes, arguments to a command are optional. If an argument is omitted, a default value is used in its place. In the case of the PIXON command, a third argument could be used that specifies the color of the pixel:

`PIXON` (*xposition*, *yposition* [,*color*]);

The last argument indicates which of four colors to use when lighting up the pixel. Here, the default value is 0 (black). In this manual, optional arguments to commands appear inside square brackets, as shown above. In the `PIXON` example, a graphics variable (G) could be specified as the first argument. The default is G0, which always contains the currently displayed screen. Thus, the full syntax for the PIXON command is:

PIXON ([*G*,] *xposition, yposition* [*,color*]);

Some built-in commands employ an alternative syntax whereby function arguments do not appear in parentheses. Examples include RETURN and RANDOM.

Program Structure

Programs can contain any number of subroutines (each of which is a function or procedure). Subroutines start with a heading consisting of the name, followed by parentheses that contain a list of parameters or arguments, separated by commas. The body of a subroutine is a sequence of statements enclosed within a BEGIN–END; pair. For example, the body of a simple program, called MYPROGRAM, could look like this:

```
EXPORT MYPROGAM()
BEGIN
PIXON(1,1);
END;
```

Comments

When a line of a program begins with two forward slashes, //, the rest of the line will be ignored. This enables you to insert comments in the program:

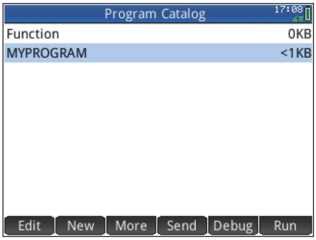
```
EXPORT MYPROGAM()
BEGIN
PIXON(1,1);
//This line is just a comment.
END;
```

The Program Catalog

The Program Catalog is where you run and debug programs, and send programs to another HP Prime. You can also rename and remove programs, and it is where you start the Program Editor. The Program Editor is where you create and edit programs. Programs can also be run from Home view or from other programs.

Open the Program Catalog

Press Shift 1 Program) to open the Program Catalog.



The Program Catalog displays a list of program names. The first item in the Program Catalog is a built-in entry that has the same name as the active app. This entry is the app program for the active app, if such a program exists. See the "App programs" on page 459 for more information.

Program Catalog: buttons and keys

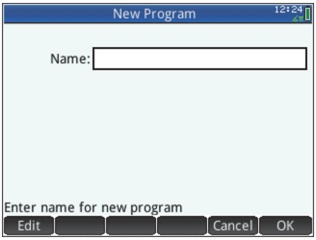
Button or Key	Purpose
Edit	Opens the highlighted program for editing.
New	Prompts for a new program name, then opens the Program Editor.
More	Opens further menu options for the selected program: • Save • Rename • Sort • Delete • Clear These options are described immediately below. To redisplay the initial menu, press On Off or Esc Clear.

Button or Key	**Purpose (Continued)**
More 1 Save 2 Rename 3 Sort › 4 Delete 5 Clear More	**Save** creates a copy of the selected program with a new name you are prompted to give. **Rename** renames the selected program. **Sort** sorts the list of programs. (Sort options are alphabetical and chronological). **Delete** deletes the selected program. **Clear** deletes all programs.
Send	Transmits the highlighted program to another HP Prime or to a PC.
Debug	Debugs the selectedprogram.
Run	Runs the highlighted program.
Shift ▲ or Shift ▼	Moves to the beginning or end of the Program Catalog.
Del	Deletes the selected program.
Shift Esc Clear	Deletes all programs.

Creating a new program

1. Open the Program Catalog and start a new program.

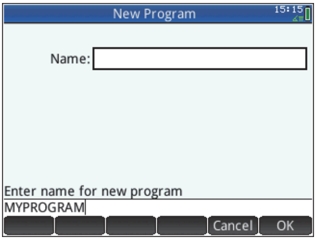
   Shift 1 (Program)
   New



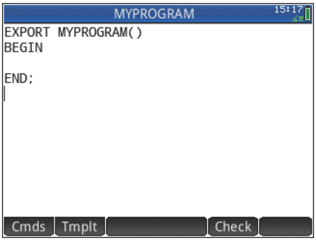
2. Enter a name for the program.

   ALPHA ALPHA (to lock alpha mode)

   MYPROGRAM
   OK.



3. Press OK again. A template for your program is then automatically created. The template consists of a heading for a function with the same name as the program, `EXPORT MYPROGRAM()`, and a `BEGIN–END;` pair that will enclose the statements for the function.



HINT A program name can contain only alphanumeric characters (letters and numbers) and the underscore character. The first character must be a letter. For example, `GOOD_NAME` and `Spin2` are valid program names, while `HOT STUFF` (contains a space) and `2Cool!` (starts with number and includes !) are not valid.

The Program Editor

Until you become familiar with the HP Prime commands, the easiest way to enter commands is to select them from the Catalog menu (Mem Catlg), or from the Commands menu in the Program Editor (Cmds). To enter variables, symbols, mathematical functions, units, or characters, use the keyboard keys.

Program Editor: buttons and keys

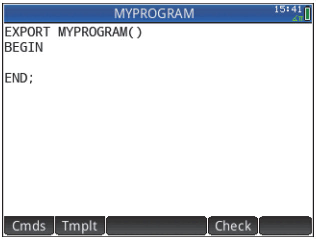
The buttons and keys in the Program Editor are: Entering a program

Button or Key	Meaning
Check	Checks the current program for errors.
Page or Shift ▲ and Shift ▼	If your programs goes beyond one screen, you can quickly jump from screen to screen by tapping either side of this button. Tap the left side of the button to display the previous page; tap the right side to display the next page. (The left tap will be inactive if you have the first page of the program displayed.)
Cmds	Opens a menu from which you can choose from common programming commands. The commands are grouped under the options: • Strings • Drawing • Matrix • App Functions • Integer • I/O • More Press Esc Clear to return to the main menu. The commands in this menu are described in “Commands under the Cmds menu”, beginning on page 470.

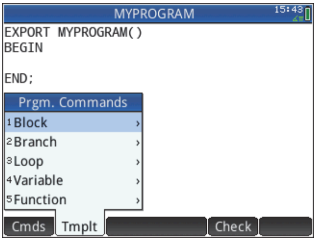
Button or Key	Meaning (Continued)
Tmplt	Opens a menu from which you can select common programming commands. The commands are grouped under the options: • Block • Branch • Loop • Variable • Function Press Esc Clear to return to the main menu. The commands in this menu are described in "Commands under the Tmplt menu", beginning on page 465.
Vars Chars A	Displays menus for selecting variable names and values.
Shift Vars Chars A (Chars)	Displays a palette of characters. If you display this palette while a program is open, you can choose a character and it will be be added to your program at the cursor point. To add one character, highlight it and tap OK or press Enter ≈. To add a character *without* closing the characters palette, select it and tap Echo.
Shift ▶ and Shift ◀	Moves the cursor to the end (or beginning) of the current line.
Enter ≈	Starts a new line.
⌫ Del	Deletes the character to the left of the cursor.

Button or Key	Meaning (Continued)
Shift Del	Deletes the character to the right of the cursor.
Shift Esc Clear	Deletes the entire program.

1. To continue the MYPROGRAM example (which we began on page 441), use the cursor keys to position the cursor where you want to insert a command. In this example, you need to position the cursor between `BEGIN` and `END`.

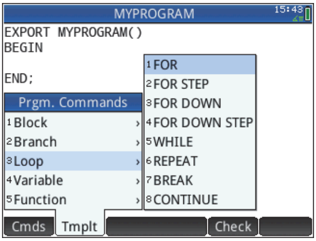


2. Tap Tmplt to open the menu of common programming commands for blocking, branching, looping, variables, and functions.

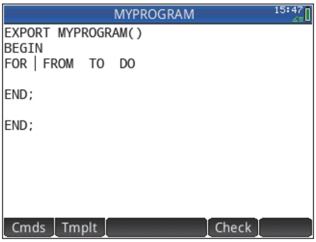


   In this example we'll select a LOOP command from the menu.

3. Select `Loop` and then select `FOR` from the sub-menu.

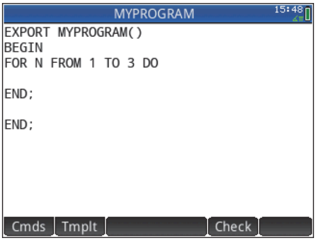


   Notice that a FOR_FROM_TO_DO_ template is inserted. All you need do is fill in the missing information.

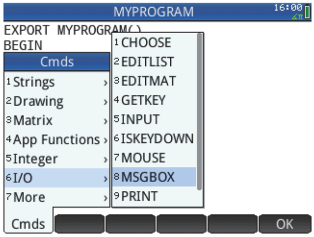


4. Using the cursor keys and keyboard, fill in the missing parts of the command. In this case, make the statement match the following:

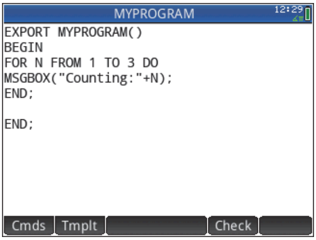
   `FOR N FROM 1 TO 3 DO`



5. Move the cursor to a blank line below the FOR statement.
6. Tap Cmds to open the menu of common programming commands.
7. Select `I/O` and then select `MSGBOX` from the sub-menu.



8. Fill in the argument of the `MSGBOX` command, and type a semicolon at the end of the command.



9. Tap Check to check the syntax of your program.
10. When you are finished, press Shift 1 (Program) to return to the Program Catalog or Home (Settings) to go to Home view. You are ready now to execute the program.

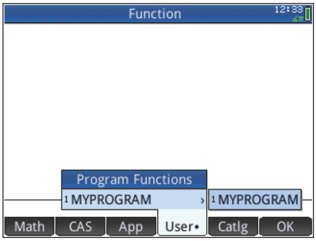
Run a Program

From Home view, enter the name of the program, with a pair of parentheses after it. If the program takes any arguments, insert these in the parentheses, separated by commas. To run the program, press Enter.

From the Program Catalog, highlight the program you want to run and tap Run. When a program is executed from the catalog, the system looks for a function named

`START ()` (no parameters). If it finds one, that function is run. Otherwise, it looks for a function with the same name as the program. If the system finds one, it runs it. Otherwise, nothing happens.

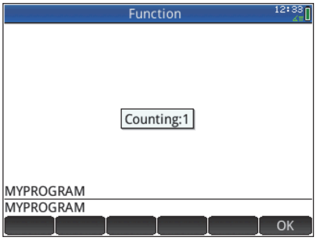
You can also run a program from the USER menu (one of the Toolbox menus):



User

Tap MYPROGRAM and `MYPROGRAM` appears on the entry line. Tap Enter and the program executes, displaying a message box.

Tap OK three times to step through the `FOR` loop. Notice that the number shown increments by 1 each time.



After the program terminates, you can resume any other activity with the HP Prime.

If a program has arguments, when you press Run a screen appears prompting you to enter the program parameters.

What you see will differ slightly depending on where you started the program. If you start the program from the Home view, the HP Prime displays the contents of `Ans` (Home variable containing the last result) when the program has finished. If you start the program from the Program Catalog by tapping the Run button, the HP Prime returns you to the Program Catalog when the program ends.

Multi-function programs

If there is more than one EXPORT function in a program, when Run is tapped a list appears for you to choose which function to run. To see this feature, create a program with the text:

```
EXPORT NAME1( )
```

```
BEGIN

END;
EXPORT NAME2( )
BEGIN

END;
```

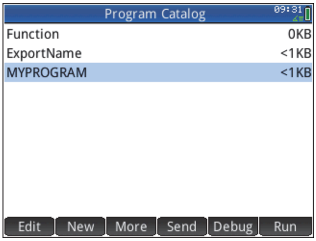
Now note that when you tap **Run** or **Debug**, a list with `NAME1` and `NAME2` appears.

Debug a Program

You cannot run a program that contains syntax errors. If the program does not do what you expect it to do, or if there is a run-time error detected by the system, you can execute the program step by step, and look at the values of local variables.

Let's debug the program created above: MYPROGRAM.

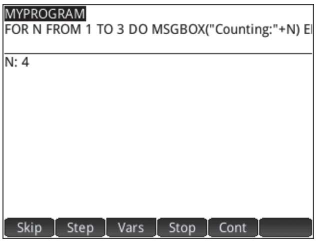
1. In the Program Catalog, select MYPROGRAM.

   Shift **1** (Program)

   Select MYPROGRAM

2. Tap **Debug**.

   If there is more than one EXPORT function in a file, a list appears for you to choose which function to debug.

   While debugging a program, the title of the program appears at the top of the display. Below that is the current line of the program being debugged. The current value of each variable is visible in the main body of the screen. The following menu buttons are available in the debugger:

   Skip: Skips to the next line of the program

   Step: Executes the current line

Vars: Opens a menu of variables

Stop: Closes the debugger

Cont: Continues program execution without debugging

3. Execute the FOR loop command.

   Step

   The `FOR` loop starts and the top of the display shows the next line of the program (the MSGBOX command).

4. Execute the MSGBOX command.

   Step

   The message box appears. Note that when each message box is displayed, you still have to dismiss it by tapping OK or pressing Enter.

   Tap Step and press Enter repeatedly to execute the program step-by-step.

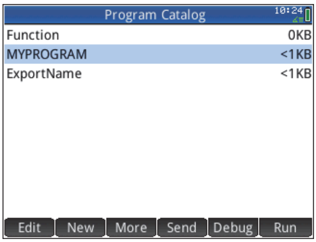
Tap Stop to close the debugger at the current line of the program, or tap Cont to run the rest of the program without using the debugger.

Edit a program

You edit a program using the Program Editor, which is accessible from the Program Catalog.

1. Open the Program Catalog.

   Shift 1 Program



2. Tap the program you want to edit (or use the arrow keys to highlight it and press Enter).

   The HP Prime opens the Program Editor. The name of your program appears in the title bar of the display. The buttons and keys you can use to edit your program are listed in “Program Editor: buttons and keys” on page 442.

Copy a program or part of a program

You can use the global `Copy` and `Paste` commands to copy part or all of a program. The following steps illustrate the process:

1. Open the Program Catalog.

   Shift 1 Program Y

2. Tap the program that has the code you want to copy.
3. Press Shift View Copy (Copy).

   The menu buttons change to give you options for copying:

   Begin: Marks where the copying or cutting is to begin.

   End: Marks where the copying or cutting is to end.

   All: Select the entire program.

   Cut: Cut the selection.

   Copy: Copy the selection.

4. Select what you want to copy or cut (using the options listed immediately above).
5. Tap Copy or Cut.
6. Return to the Program Catalog and open the target program.
7. Move the cursor to where you want to insert the copied or cut code.
8. Press Shift Menu Paste (Paste). The clipboard opens. What you most recently copied or cut will be first in the list and highlighted already, so just tap OK. The code will be pasted into the program, beginning at the cursor location.

Delete a program

To delete a program:

1. Open the Program Catalog.

   Shift 1 Program Y

2. Highlight a program to delete and press Del.
3. At the prompt, tap OK to delete the program or Cancel to cancel.

Delete all programs

To delete all programs at once:

1. Open the Program Catalog.

   Shift 1 (Program)

2. Press Shift Esc (Clear).
3. At the prompt, tap OK to delete all programs or Cancel to cancel.

Delete the contents of a program

You can clear the contents of a program without deleting the program. The program then just has a name and nothing else.

1. Open the Program Catalog.

   Shift 1 (Program)

2. Tap the program to open it.
3. Press Shift Esc (Clear).
4. At the prompt, tap OK to delete the contents or Cancel to cancel.

   The text of the program is deleted, but the program name remains.

To share a program

You can send programs between calculators just as you can send apps, notes, matrices, and lists. See “Sharing data” on page 40.

The HP Prime programming language

Variables and visibility

Variables in an HP Prime program can be used to store numbers, lists, matrices, graphics objects, and strings. The name of a variable must be a sequence of alphanumeric characters (letters and numbers), starting with a letter. Names are case-sensitive, so the variables named MaxTemp and maxTemp are different.

The HP Prime has built-in variables of various types, visible globally (that is, visible wherever you are in the calculator). For example, the built-in variables A to Z can be used to store real numbers, Z0 to Z9 can be used to store complex numbers, M0 to M9 can be used to store Matrices and vectors, and so on. These names are reserved. You cannot use them for other data. For example, you cannot name a program M1, or store a real number in a variable named Z8. In addition to these reserved variables, each HP app has its own reserved variables. Some examples are `Root`, `Xmin`, and `Numstart`. Again, these names cannot be used to name a program. (A full list of system and app variables is given in chapter 21, "Variables", beginning on page 373.)

In a program you can declare variables for use only within a particular function. This is done using a `LOCAL` declaration. The use of `LOCAL` variables enables you to declare and use variables that will not affect the rest of the calculator. `LOCAL` variables are not bound to a particular type, that is, you can store floating-point numbers, integers, lists, matrices, and symbolic expressions in a variable with any local name. Although the system will allow you to store different types in the same local variable, this is poor programming practice and should be avoided.

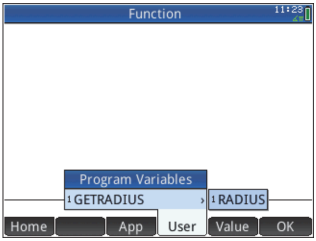
Variables declared in a program should have descriptive names. For example, a variable used to store the radius of a circle is better named `RADIUS` than `VGFTRFG`. You are more likely to remember what the variable is used for if its name matches its purpose.

If a variable is needed after the program executes, it can be exported from the program using the `EXPORT` command. To do this, the first command in the program (that is, on a line above the program name) would be `EXPORT RADIUS`. Then, if a value is assigned to `RADIUS`, the name appears on the variables menu (Vars) and is visible globally. This feature allows for extensive and powerful interactivity among different environments in the HP Prime. Note that if another program exports a variable with the same name, the most recently exported version will be active.

The program below prompts the user for the value of `RADIUS`, and exports the variable for use outside the program.

```
EXPORT RADIUS;
EXPORT GETRADIUS()
BEGIN
```

```
    INPUT(RADIUS);
    END;
```



Note that EXPORT command for the variable RADIUS appears before the heading of the function where RADIUS is assigned. After you execute this program, a new variable named RADIUS appears on the USER GETRADIUS section of the Variables menu.

Qualifying the name of a variable

The HP Prime has many system variables with names that are apparently the same. For example, the Function app has a variable named Xmin, but so too does the Polar app, the Parametric app, the Sequence app, and the Solve app. In a program, and in the Home view, you can refer to a particular version of these variables by qualifying its name. This is done by entering the name of the app (or program) that the variable belongs to, followed by a dot (.), and then the actual variable name. For example, the qualified variable Function.Xmin refers to the value of Xmin within the Function app. Similarly, the qualified variable Parametric.Xmin refers to the value of Xmin in the Parametric app. Despite having the same name—Xmin—the variables could have different values. You do likewise to declare a local variable in a program: specify the name of the program, followed by the dot, and then variable name.

Functions, their arguments, and parameters

You can define your own functions in a program, and data can be passed to a function using parameters. Functions can return a value (using the RETURN statement) or not. When a program is executed from Home view, the program will return the value returned by the *last* statement that was executed.

Furthermore, functions can be defined in a program and exported for use by other programs, in much the same way that variables can be defined and used elsewhere.

In this section, we will create a small set of programs, each illustrating some aspect of programming in the HP Prime. Each program will be used as a building block for a custom app described in the next section, *App Programs*.

Program ROLLDIE

We'll first create a program called ROLLDIE. It simulates the rolling of a single die, returning a random integer between 1 and whatever number is passed into the function.

In the Program Catalog create a new program named ROLLDIE. (For help, see page 441.) Then enter the code in the Program Editor.

```
EXPORT ROLLDIE(N)
BEGIN
RETURN 1+FLOOR(RANDOM(N));
END;
```

The first line is the heading of the function. Execution of the RETURN statement causes a random integer from 1 to N to be calculated and returned as the result of the function. Note that the RETURN command causes the execution of the function to terminate. Thus any statements between the RETURN statement and END are ignored.

In Home view (in fact, anywhere in the calculator where a number can be used), you can enter ROLLDIE(6) and a random integer between 1 and 6 inclusive will be returned.

Program ROLLMANY

Another program could use the ROLLDIE function, and generate *n* rolls of a die with any number of sides. In the following program, the ROLLDIE function is used to generate *n* rolls of two dice, each with the number of sides given by the local variable sides. The results are stored in list L2, so that L2(1) shows the number of times the dies came up with a combined total of 1, L2(2) shows the number of times the dies came up with a combined total of 2, etc. L2(1) should be 0 (since the sum of the numbers on 2 dice must be at least 2).

```
EXPORT ROLLMANY(n,sides)
BEGIN
LOCAL k,roll;
```

```
// initialize list of frequencies
MAKELIST(0,X,1,2*sides,1)▶L2;
FOR k FROM 1 TO n DO
ROLLDIE(sides)+ROLLDIE(sides)▶roll;
L2(roll)+1▶L2(roll);
END;
END;
```

By omitting the EXPORT command when a function is declared, its visibility can be restricted to the program within which it is defined. For example, you could define the ROLLDIE function inside the ROLLMANY program like this:

```
ROLLDIE();
EXPORT ROLLMANY(n,sides)
BEGIN
 LOCAL k,roll;
 // initialize list of frequencies
 MAKELIST(0,X,1,2*sides,1)▶L2;
 FOR k FROM 1 TO n DO
ROLLDIE(sides)+ROLLDIE(sides)▶roll;
   L2(roll)+1▶L2(roll);
 END;
END;
ROLLDIE(n)
BEGIN
RETURN 1+FLOOR(RANDOM(N));
END;
```

In this scenario, assume there is no ROLLDIE function exported from another program. Instead, ROLLDIE is visible only to ROLLMANY. The ROLLDIE function must be declared before it is called. The first line of the program above contains the declaration of the ROLLDIE function. The definition of the ROLLDIE function is located at the end of the program.

Finally, the list of results could be returned as the result of calling ROLLMANY instead of being stored directly in the global list variable, L2. This way, if the user wanted to store the results elsewhere, it could be done easily.

```
EXPORT ROLLMANY(n,sides)
BEGIN
 LOCAL k,roll,results;
 MAKELIST(0,X,1,2*sides,1)▶results;
 FOR k FROM 1 TO n DO
ROLLDIE(sides)+ROLLDIE(sides)▶roll;
   results(roll)+1▶results(roll);
 END;
RETURN results;
END;
```

In Home view you would enter `ROLLMANY(100,6)▶ L5` and the results of the simulation of 100 rolls of two six-sided dice would be stored in list L5.

The User Keyboard: Customizing key presses

You can assign alternative functionality to any key on the keyboard, including to the functionality provided by the shift and alpha keys. This enables you to customize the keyboard to your particular needs. For example, you could assign [SIN ASIN G] to a function that is multi-nested on a menu and thus difficult to get to on a menu (such as ALOG).

A customized keyboard is called the *user keyboard* and you activate it when you go into *user mode*.

User mode

There are two user modes:

- Temporary user mode: the next key press, and only the next, enters the object you have assigned to that key. After entering that object, the keyboard automatically returns to its default operation.

  To activate temporary user mode, press [Shift] [Help User] (User). Notice that **1U** appears in the title bar. The **1** will remind you that the user keyboard will be active for just one key press.

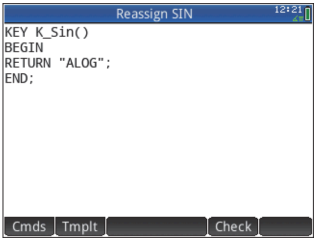
- Persistent user mode: each key press *from now until you turn off user mode* will enter whatever object you have assigned to a key.

To activate persistent user mode, press Shift Help/User Shift Help/User. Notice that ⬆U appears in the title bar. The user keyboard will now remain active until you press Shift Help/User again.

If you are in user mode and press a key that hasn't been re-assigned, the key's standard operation is performed.

Re-assigning keys

Suppose you want to assign a commonly used function—such as ALOG—to its own key on the keyboard. Simply create a new program that mimics the syntax in the image at the right.



The first line of the program specifies the key to be reassigned using its internal name. (The names of all the keys are given in "Key names" on page 456. They are case-sensitive.)

On line 3, enter the text you want produced when the key being re-assigned is pressed. This text must be enclosed in quote marks.

The next time you want to insert `ALOG` at the position of your cursor, you just press Shift Help/User SIN.

You can enter any string you like in the RETURN line of your program. For example, if you enter "M4", matrix M4 will be returned when you press the re-assigned key. You can even get the program to return user-defined functions as well as system functions, and user-defined variables as well as system variables.

You can also re-assign a shifted key combination. So, for example, ALPHA Shift ÷ could be re-assigned to produce `SLOPE(F1(X),3)` rather than the lowercase *t*. Then if ALPHA Shift ÷ is entered in Home view and Enter pressed, the gradient at X = 3 of whatever function is currently defined as F1(X) in the Function app would be returned.

Key names

The first line of a program that re-assigns a key must specify the key to be reassigned using its internal name.

The table below gives the internal name for each key. Note that key names are case-sensitive.

Internal name of keys and key states

Key	Name	Shift + key	ALPHA + key	ALPHA Shift + key
0 Notes " "	K_0	KS_0	KA_0	KSA_0
1 Program Y	K_1	KS_1	KA_1	KSA_1
2 *i* Z	K_2	KS_2	KA_2	KSA_2
3 π #	K_3	KS_3	KA_2	KSA_2
4 Matrix U	K_4	KS_4	KA_4	KSA_4
5 [ ] V	K_5	KS_5	KA_5	KSA_5
6 ≤,≥,≠ W	K_6	KS_6	KA_6	KSA_6
7 List Q	K_7	KS_7	KA_7	KSA_7
8 { } R	K_8	KS_8	KA_8	KSA_8
9 !,∞,→ S	K_9	KS_9	KA_9	KSA_9
a b/c ° ′ ″ E	K_Abc	KS_Abc	KA_Abc	KSA_Abc
ALPHA alpha	K_Alpha	KS_Alpha	KA_Alpha	KSA_Alpha
Apps Info	K_Apps	KS_Apps	KA_Apps	KSA_Apps
⌫ Del	K_Bksp	KS_Bksp	KA_Bksp	KSA_Bksp
, Eval O	K_Comma	KS_Comma	KA_Comma	KSA_Comma
COS ACOS H	K_Cos	KS_Cos	KA_Cos	KSA_Cos
÷ x^{-1} T	K_Div	KS_Div	KA_Div	KSA_Div
. =	K_Dot	KS_Dot	KA_Dot	KSA_Dot
▼	K_Down	KS_Down	KA_Down	KSA_Down
Enter ≈	K_Enter	KS_Enter	KA_Enter	KSA_Enter
Home Settings	K_Home	KS_Home	KA_Home	KSA_Home
◀	K_Left	KS_Left	KA_Left	KSA_Left
▶	K_Right	KS_Right	KA_Right	KSA_Right

Internal name of keys and key states				
Key	Name	Shift + key	ALPHA alpha + key	ALPHA alpha Shift + key
LN e^x J	K_Ln	KS_Ln	KA_Ln	KSA_Ln
LOG 10^x K	K_Log	KS_Log	KA_Log	KSA_Log
− Base :	K_Minus	KS_Minus	KA_Minus	KSA_Minus
+/− |x| M	K_Neg	KS_Neg	KA_Neg	KSA_Neg
Num Setup	K_Num	KS_Num	KA_Num	KSA_Num
On Off	K_On	KS_On	KA_On	KSA_On
Plot Setup	K_Plot	KS_Plot	KA_Plot	KSA_Plot
+ Ans ;	K_Plus	KS_Plus	KA_Plus	KSA_Plus
x^y $\sqrt[n]{}$ F	K_Power	KS_Power	KA_Power	KSA_Power
SIN ASIN G	K_Sin	KS_Sin	KA_Sin	KSA_Sin
x^2 $\sqrt{}$ L	K_Sq	KS_Sq	KA_Sq	KSA_Sq
Symb Setup	K_Symb	KS_Symb	KA_Symb	KSA_Symb
TAN ATAN I	K_Tan	KS_Tan	KA_Tan	KSA_Tan
▲	K_Up	KS_Up	KA_Up	KSA_Up
Vars Chars A	K_Vars	KS_Vars	KA_Vars	KSA_Vars
View Copy	K_View	KS_View	KA_View	KSA_View
$x\,t\,\theta\,n$ Define D	K_Xttn	KS_Xttn	KA_Xttn	KSA_Xttn
Help User				
Menu Paste				
Esc Clear				
CAS Settings				
Mem B				
Units C				
( ) N				
EEX Sto▸ P				

Internal name of keys and key states				
Key	**Name**	Shift + key	ALPHA alpha + key	ALPHA alpha Shift + key
×				
Shift				
␣				

App programs

An app is a unified collection of views, programs, notes, and associated data. Creating an app program allows you to redefine the app's views and how a user will interact with those views. This is done with (a) dedicated program functions with special names and (b) by redefining the views in the Views menu.

Using dedicated program functions

These programs are run when the keys shown in the table below are pressed. These program functions are designed to be used in the context of an app.

Program	**Name**	**Equivalent Keystrokes**
Symb	Symbolic view	Symb Setup
SymbSetup	Symbolic Setup	Shift Symb Setup
Plot	Plot view	Plot Setup
PlotSetup	Plot Setup	Shift Plot Setup
Num	Numeric view	Num Setup
NumSetup	Numeric Setup	Shift Num Setup
Info	Info view	Shift Apps Info
START	Starts an app	Start
RESET	Resets or initializes an app	Reset

Redefining the Views menu

The Views menu allows any app to define views in addition to the standard seven views shown in the table above. By default, each HP app has its own set of additional views contained in this menu. The `VIEWS` command allows you to redefine these views to run programs you have created for an app. The syntax for the `VIEWS` command is:

`VIEWS` "*text*"

By adding `VIEWS` "*text*" before the declaration of a function, you will override the list of views for the app. For example, if your app program defines three views—"*SetSides*", "*RollDice*" and "*PlotResults*"—when you press View/Copy you will see *SetSides*, *RollDice*, and *PlotResults* instead of the app's default view list.

Customizing an app

When an app is active, its associated program appears as the first item in the Program Catalog. It is within this program that you put functions to create a custom app. A useful procedure for customizing an app is illustrated below:

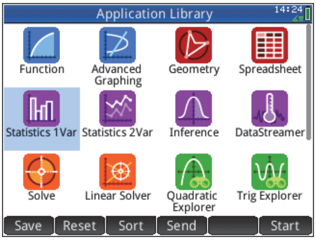
1. Decide on the HP app that you want to customize. The customized app inherits all the properties of the HP app.
2. Go to the Applications Library (ALPHA/alpha), highlight the HP app, tap Save and save the app with a unique name.
3. Customize the new app if you need to (for example, by configuring the axes or angle measure settings).
4. Develop the functions to work with your customized app. When you develop the functions, use the app naming conventions described above.
5. Put the `VIEWS` command in your program to modify the app's Views menu.
6. Decide if your app will create new global variables. If so, you should `EXPORT` them from a separate user program that is called from the `Start()` function in the app program. This way they will not have their values lost.
7. Test the app and debug the associated programs.

It is possible to link more than one app via programs. For example, a program associated with the Function app could execute a command to start the Statistics 1Var app, and a program associated with the Statistics 1Var app could return to the Function app (or launch any other app).

Example

The following example illustrates the process of creating a custom app. The app is based on the built-in Statistics 1Var app. It simulates the rolling of a pair of dice, each with a number of sides specified by the user. The results are tabulated, and can be viewed either in a table or graphically.

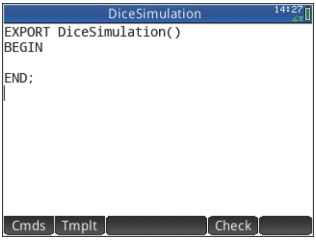
1. In the Application Librray, select the Statistics 1Var app but don't open it.

   Apps Info Select `Statistics 1Var`.
2. Tap Save.
3. Enter a name for the new app (such as `DiceSimulation`.)
4. Tap OK twice.

   The new app appears in the Application Library.
5. Open the new app.
6. Open the Program Catalog.

   Shift 1 Program
7. Tap the program to open it.

   Each customised app has one program associated with it. Initially, this program is empty. You customize the app by entering functions into that program.

At this point you decide how you want the user to interact with the app. In this example, we will want the user to be able to:

- start the app
- specify the number of sides (that is, faces) on each die
- specify number of times to roll the dice
- start the app again.

With that in mind, we will create the following views:

START, SETSIDES, and SETNUMROLLS.

The START option will initialize the app and display a note that gives the user instructions. The user will also interact with the app through the Numeric view and the Plot view. These views will be activated by pressing Num Setup and Plot Setup, but the functions Num and Plot in our app program will actually launch those views after doing some configuration.

The program discussed earlier in this chapter to get the number of sides for a dice is expanded here, so that the possible sums of two such die are stored in dataset D1. Enter the following sub-routines into the program for the DiceSimulation app.

The program DiceSimulation

```
START()
BEGIN
DICESIMVARS();
{}▶D1;
{}▶D2;
SetSample(H1,D1);
SetFreq(H1,D2);
0▶H1Type;
END;
VIEWS "Roll Dice",ROLLMANY()
BEGIN
LOCAL k,roll;
MAKELIST(X+1,X,1,2*SIDES-1,1)▶D1;
MAKELIST(X+1,X,1,2*SIDES-1,1)▶D2;
FOR k FROM 1 TO ROLLS DO
roll:=ROLLDIE(SIDES)+ROLLDIE (SIDES);
D2(roll-1)+1▶D2(roll-1);
END;
```

```
-1▶Xmin;
MAX(D1)+1▶Xmax;
0▶Ymin;
MAX(D2)+1▶Ymax;
STARTVIEW(1,1);
END;
VIEWS "Set Sides",SETSIDES()
BEGIN
REPEAT
INPUT(SIDES,"Die Sides","N=","ENTER
num sides",2);
FLOOR(SIDES)▶SIDES;
IF SIDES<2 THEN
MSGBOX("Must be >= 2");
END;
UNTIL SIDES >=2;
END;
VIEWS "Set Rolls",SETROLLS()
BEGIN
REPEAT
INPUT(ROLLS,"Num of rolls","N=","Enter
numrolls",25);
FLOOR(ROLLS)▶ROLLS;
IF ROLLS<1 THEN
MSGBOX(" u must enter a num >=1");
END;
UNTIL ROLLS>=1;
END;
PLOT()
BEGIN
-1▶Xmin;
MAX(D1)+1▶Xmax;
0▶Ymin;
MAX(D2)+1▶Ymax;
STARTVIEW(1,1);
END;
```

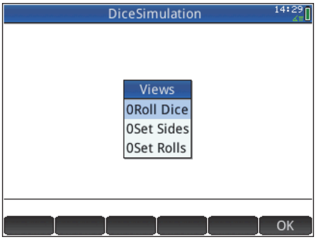
The ROLLMANY() routine is an adaptation of the program presented earlier in this chapter. Since you cannot pass parameters to a program called through a selection from a custom Views menu, the exported variables SIDES and ROLLS are used in place of the parameters that were used in the previous versions.

The program above calls two other user programs: ROLLDIE() and DICESIMVARS(). ROLLDIE() appears earlier in this chapter. Here is DICESIMVARS. Create a program with that name and enter the following code.

The program DICESIMVARS

```
EXPORT ROLLS,SIDES;
EXPORT DICESIMVARS()
BEGIN
10 ▶ ROLLS;
6 ▶ SIDES;
END;
```

Press View/Copy to see the custom app menu. Here you can set the number of sides of the dice, the number of rolls, and execute a simulation.



After running a simulation, press Plot/Setup to see a histogram of your simulation results.

Doesn’t work in build 3105

Program commands

This section describes each program command. The commands under the Tmplt menu are described first. The commands under the Cmds menu are described in “Commands under the Cmds menu” on page 470.

Commands under the Tmplt menu

Block

The block commands determine the beginning and end of a sub-routine or function. There is also a `Return` command to recall results from sub-routines or functions.

BEGIN END

Syntax: `BEGIN` *stmt1;stm2;…stmtN;* `END;`

Defines a command or set of commands to be executed together. In the simple program:

```
EXPORT SQM1(X)
BEGIN
RETURN X^2-1;
END;
```

the block is the single RETURN command.

If you entered `SQM1(8)` in Home view, the result returned would be 63.

RETURN

Syntax: `RETURN` *expression*;

Returns the current value of *expression*.

KILL

Syntax: `KILL`;

Stops the step-by-step execution of the current program (with debug).

Branch

In what follows, the plural word *commands* refers to both a single command or a set of commands.

IF THEN

Syntax: `IF` *test* `THEN` *commands* `END`;

Evaluate *test*. If *test* is true (not 0), execute *commands*. Otherwise, nothing happens.

IF THEN ELSE

Syntax: `IF` *test* `THEN` *commands1* `ELSE` *commands 2* `END`;

Evaluate *test*. If *test* is true (non 0), execute *commands 1*, otherwise, execute *commands 2*

CASE

Syntax:

`CASE`

IF *test1* THEN *commands1* END

IF *test2* THEN *commands2* END

…

[DEFAULT *commands*]

END;

Evaluates *test1*. If true, execute *commands1* and end the CASE. Otherwise, *evaluate test2*. If true, execute *commands2*. Continue evaluating tests until a true is found. If no true test is found, execute default *commands*, if provided.

Example:

```
CASE
IF x < 0 THEN RETURN "negative"; END
IF x < 1 THEN RETURN "small"; END
DEFAULT RETURN "large";
END;
```

IFERR IFERR *commands1* THEN *commands2* [ELSE *commands3*] END;

Executes sequence of *commands1*. If an error occurs during execution of *commands1*, executes sequence of *commands2*.

IFERR ELSE IFERR *commands1* THEN *commands2* ELSE *commands3* END;

Executes sequence of *commands1*. If an error occurs during execution of *commands1*, executes sequence of *commands2*. Otherwise, execute sequence of *commands3*.

Loop

FOR Syntax: FOR *var* FROM *start* TO *finish* DO *commands*

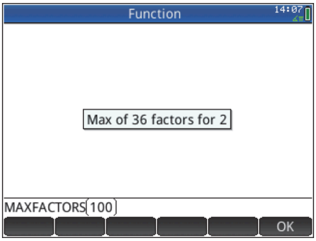
Sets variable *var* to *start*, and for as long as this variable is less than or equal to *finish*, executes the sequence of *commands*, and then adds 1 (*increment*) to *var*. If DOWNTO is used the *start* value of the variable is decreased until the *finish* value is reached.

Example 1: This program determines which integer from 2 to N has the greatest number of factors.

```
EXPORT MAXFACTORS(N)
BEGIN
LOCAL cur, max,k,result;
1▶ max;1▶ result;
FOR k FROM 2 TO N DO
 SIZE(idivis(k)) ▶ cur;
 IF cur > max THEN
  cur ▶ max;
  k ▶ result;
 END;
END;
MSGBOX("Max of "+ max +" factors for
"+result);
```

In Home, enter MAXFACTORS(100).

This syntax is not working as at build 3015.



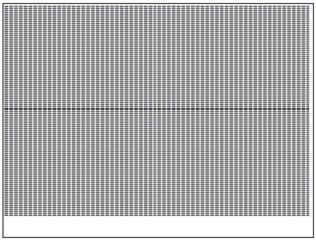
FOR STEP Syntax: FOR *var* FROM *start* TO *finish* [*STEP increment*] DO *commands*

Sets variable *var* to *start*, and for as long as this variable is less than or equal to *finish*, executes the sequence of *commands*, and then adds 1 (*increment*) to *var*.

Example 2: This program draws an interesting pattern on the screen.

```
EXPORT DRAWPATTERN()
BEGIN
 LOCAL xincr,yincr,color;
 STARTAPP("Function");
 RECT();
 xincr := (Xmax - Xmin)/254;
 yincr := (Ymax - Ymin)/110;
 FOR X FROM Xmin TO Xmax STEP xincr DO
```

```
 FOR Y FROM Ymin TO Ymax STEP yincr DO
  color := FLOOR(X^2+Y^2) MOD 4;
  PIXON(X,Y,color);
END;
 END;
FREEZE;
END;
```



FOR DOWN

Syntax: `FOR` *var* `FROM` *start* `DOWNTO` *finish* `DO` *commands*

Sets variable *var* to *start*, and for as long as this variable is less than or equal to *finish*, executes the sequence of *commands*, and then adds 1 (*increment*) to *var*. If `DOWNTO` is used the *start* value of the variable is decreased until the *finish* value is reached.

FOR DOWN STEP

Syntax: `FOR` *var* `FROM` *start* `DOWNTO` *finish* [*STEP increment*] `DO` *commands*

Sets variable *var* to *start*, and for as long as this variable is less than or equal to *finish*, executes the sequence of *commands*, and then adds 1 (*increment*) to *var*. If `DOWNTO` is used the *start* value of the variable is decreased until the *finish* value is reached.

WHILE

Syntax: `WHILE` *test* `DO` *commands* `END`;

Evaluate test. If result is true (not 0), executes the *commands*, and repeat.

Example: A perfect number is one that is equal to the sum of all its proper divisors. For example, 6 is a perfect number because 6 = 1+2+3. The example below returns true when its argument is a perfect number.

```
EXPORT ISPERFECT(n)
BEGIN
 LOCAL d, sum;
 2 ▶ d;
 1 ▶ sum;
WHILE sum < = n AND d < n DO
 IF irem(n,d)==0 THEN
```

```
  sum+d ▶ sum;
 END;
 d+1▶ d;
 END;
 RETURN sum==n;
END;
```

The following program displays all the perfect numbers up to 1000:

```
EXPORT PERFECTNUMS()
BEGIN
LOCAL k;
FOR k FROM 2 TO 1000 DO
 IF ISPERFECT(k) THEN
 MSGBOX(k+" is perfect, press OK");
 END;
END;
END;
```

REPEAT Syntax: `REPEAT` *commands* `UNTIL` *test*;

Repeats the sequence of *commands* until *test* is true (not 0).

The example below prompts for a positive value for SIDES, modifying an earlier program in this chapter:

```
EXPORT SIDES;
EXPORT GETSIDES()
BEGIN
 REPEAT
 INPUT(SIDES,"Die Sides","N = ","Enter
num sides",2);
 UNTIL SIDES>0;
END;
```

BREAK Syntax: `BREAK(`*n*`)`

Exits from loops by breaking out of *n* loop levels. Execution picks up with the first statement after the loop. With no argument exit from a single loop.

CONTINUE Syntax: `CONTINUE`

Transfer execution to the start of the next iteration of a loop.

Variable

These commands enable you to control the visibility of a user-defined variable.

LOCAL Local.

Syntax: `LOCAL` *var1,var2,…varn;*

Makes the variables var1, var2, etc. local to the program in which they are found.

EXPORT Exports the variable so that it is globally available.

Function

These commands enable you to control the visibility of a user-defined function.

EXPORT Export.

Syntax: `EXPORT (`*FunctionName*)

Exports the function `FunctionName` so that it is globally available and appears on the User menu (Mem User).

VIEW Sets text that the user can see by pressing View Copy.

KEY A prefix to a key name when creating a user keyboard. See “The User Keyboard: Customizing key presses” on page 455.

Commands under the Cmds menu

Strings

A string is a sequence of characters enclosed in double quotes (""). To put a double quote in a string, use two consecutive double quotes. The \ character starts an escape sequence, and the character(s) immediately following are interpreted specially. *n* inserts a new line and two backslashes insert a single backslash. To put a new line into the string, press Enter to wrap the text at that point.

ASC Syntax: `asc`(*str*)

Returns a vector containing the ASCII codes of string *str*.

Example: `asc`(*"AB"*) returns [65,66]

CHAR Syntax: `char`(*vector or int*)

Returns the string corresponding to the character codes in *vector*, or the single code *int*.

Examples: `char`(*65*) returns "A"; `char`([82,77,72]) returns "RMH"

DIM Syntax: `dim`(*str*)

Returns the number of characters in string *str*.

Example: `dim`(*"12345"*) returns 5, `dim`(*""""*) and `dim`(*"\n"*) return 1. (Notice the use of the two double quotes and the escape sequence.)

STRING Syntax: `string`(*object*);

Returns a string representation of the *object*. The result varies depending on the type of *object*.

`string`(*2/3*); results in `string`(*"2/3"*)

Examples:

String	**Result**
`string`(2/3)	"0.666666666667"
`string`(F1), when F1(X) = COS(X)	"COS(X)"
`string`(L1) when L1 = {1,2,3}	"{1,2,3}"
`string`(M1) when M1 = $\begin{bmatrix}1 & 2 & 3\\4 & 5 & 6\end{bmatrix}$	"[[1,2,3],[4,5,6]]"

INSTRING Syntax: `inString`(*str1,str2*)

Returns the index of the first occurrence of *str2* in *str1*. Returns 0 if *str2* is not present in *str1*. Note that the first character in a string is position 1.

Examples:

`inString` (*"vanilla","van"*) returns 1.

`inString` (*"banana","na"*) returns 3

`inString` (*"ab","abc"*) returns 0

LEFT

Syntax: `left`(*str,n*)

Return the first *n* characters of string *str*. If $n \geq dim(str)$ or $n < 0$, returns *str*. If *n* == 0 returns the empty string.

Example: `left`(*"MOMOGUMBO",3*) returns "MOM"

RIGHT

Syntax: right(*str,n*)

Returns the last n characters of string *str*. If *n* <= 0, returns empty string. If *n* > –*dim(str)*, returns str

Example: `right`("MOMOGUMBO",5) returns "GUMBO"

MID

Syntax: `mid`(*str,pos,* [*n*])

Extracts *n* characters from string *str* starting at index *pos*. *n* is optional, if not specified, extracts all the remainder of the string.

Example: `mid`(*"MOMOGUMBO",3,5*) returns "MOGUM", `mid`(*"PUDGE",4*) returns "GE"

ROTATE

Syntax: `rotate`(*str,n*)

Permutation of characters in string *str*. If 0 <=*n* < *dim(str)*, shifts *n* places to left. If –*dim(str)* < *n* <= –1, shifts *n* spaces to right. If *n* > *dim(str)* or *n* < -*dim(str)*, returns *str*.

Examples:

`rotate`(*"12345",2*) returns "34512"
`rotate`(*"12345",-1*) returns "51234"
`rotate`(*"12345",6*) returns "12345"

STRINGFROMID

Syntax: STRINGFROMID(*integer*)

Returns, in the current language, the built-in string associated in the internal string table with the specified *integer*.

Examples:

STRINGFROMID(*56*) returns “Complex”

STRINGFROMID(*202*) returns “Home Vars”

REPLACE

Syntax: REPLACE(object_1, start, object_2)

Replaces part of $object_1$ with $object_2$ beginning at *start*. The objects can be matrices, vectors, or stings.

Example:

`REPLACE(`*"12345",3,"99"*) returns "12995"

Drawing

There are 10 built-in graphics variables in the HP Prime, called *G0–G9*. *G0* is always the current screen graphic.

G1 to *G9* can be used to store temporary graphic objects (called *GROBs* for short) when programming applications that use graphics. They are temporary and thus cleared when the calculator turns off.

Twenty-six functions can be used to modify graphics variables. Thirteen of them work with Cartesian coordinates using the Cartesian plane defined in the current app by the variables *Xmin, Xmax, Ymin,* and *Ymax*.

The remaining thirteen work with pixel coordinates where the pixel `0,0` is the top left pixel of the *GROB*, and `255,126` is the bottom right. Functions in this second set have a *_P* suffix to the function name.

C→PX Converts from Cartesian coordinates to screen coordinates.

DRAWMENU Syntax: DRAWMENU({$text_1$, $text_2$, …})

Draws a menu showing the text items listed.

FREEZE Syntax: `FREEZE`

Pauses program execution until a key is pressed. This prevents the screen from being redrawn after the end of the program execution, leaving the modified display on the screen for the user to see.

PX→C Converts from screen coordinates to Cartesian coordinates.

Pixels and Cartesian

ARC_P

ARC Syntax; `ARC(`*G, x, y, r* [, *a1, a2, c*])

`ARC_P(`*G, x, y, r* [*, a1, a2, c*])

Draws an arc or circle on *G*, centered on point *x,y*, with radius *r* and color *c* starting at angle *a1* and ending on angle *a2*.

G can be any of the graphics variables and is optional. The default is *G0*

r is given in pixels.

c is optional and if not specified black is used.

a1 and *a2* follow the current angle mode and are optional. The default is a full circle.

BLIT_P

BLIT Syntax: `BLIT(`[*trgtGRB, dx1, dy1, dx2, dy2*], *srcGRB* [*,sx1, sy1, sx2, sy2, c*])

`BLIT_P` ([*trgtGRB, dx1, dy1, dx2, dy2*], *srcGRB* [*,sx1, sy1, sx2, sy2, c*])

Copies the region of *srcGRB* between point *sx1, sy1* and *sx2, sy2* into the region of *trgtGRB* between points *dx1, dy1* and *dx2, dy2*. Do not copy pixels from *srcGRB* that are color *c*.

trgtGRB can be any of the graphics variables. *trgtGRB* can be any of the graphics variables and is optional. The default is G0.

srcGRB can be any of the graphics variables.

dx2, dy2 are optional and if not specified will be calculated so that the destination area is the same size as the source area.

sx2, sy2 are optional and if not specified will be the bottom right of the *srcGRB*.

sx1, sy1 are optional and if not specified will be the top left of *srcGRB*.

dx1, dy1 are optional and if not specified will be the top left of *trgtGRB*.

c can be `0` to `3` (`0`=black, `1`= dark gray, `2`= light gray, `3`= white). *c* is optional. If not specified all pixels from *G2* will be copied.

NOTE Using the same variable for *trgtGRB* and *srcGRB* can be unpredictable when the source and destination overlap.

DIMGROB_P

DIM_GROB

Syntax: `DIMGROB` (*G, w, h* [,*c*]) or `DIMGROB` (*G* [,*line_1, line_2,…,line_h*])

`DIMGROB` (*G, w, h* [,*c*]) or `DIMGROB` (*G* [,*line_1, line_2,…,line_h*])

Sets the dimensions of *GROB G* to w*h. Initializes the graphic *G* with color *c* or with the graphic data provided in the list. *G* can be any graphics variable except G0. *c* can be `0` to `3` (`0`=black, `1`= dark gray, `2`= light gray, `3`= white). *c* is optional. The default is white.

If the graphic is initialized using graphic data, the list must have as many numbers as the height of the *GROB*. Each number, as seen in base 16, describes a line. Two bits are used for each pixel (`00`=black, `01`=dark gray, `10`=light gray, `11`=white). Hence, each hex digit describes two pixels.

You can enter hexadecimal numbers using the `0xdigits` syntax.

The first pixel of the line is defined by the least significant bit of the number; the 2nd pixel by the second least significant bit, etc.

GETPIX_P

GETPIX

Syntax: `GETPIX`([*G*], *xposition, yposition*)

`GETPIX_P` ([*G*], *xposition, yposition*)

Returns the color of the pixel *G* with coordinates *x,y*.

G can be any of the graphics variables and is optional. The default is *G0*, the current graphic.

GROBH_P

GROBH

Syntax: `GROBH` (*G*)

`GROBH_P` (*G*)

Returns the height of *G*.

G can be any of the graphics variables and is optional. The default is *G0*.

GROBW_P

GROBW Syntax: `GROBW(`*G*`)`

`GROBW_P(`*G*`)`

Returns the width of *G*.

G can be any of the graphics variables and is optional. The default is *G0*.

INVERT_P

INVERT Syntax: `INVERT(`[*G, x1, y1, x2, y2*]`)`

`INVERT_P(`[*G, x1, y1, x2, y2*]`)`

Inverts a rectangle on *G* between points *x1,y1* and *x2,y2*. This means that every black pixel becomes white and vice-versa. In the same way Light gray and dark gray are inverted. *G* can be any of the graphics variables and is optional. The default is *G0*.

x2, y2 are optional and if not specified will be the bottom right of the graphic.

x1, y1 are optional and if not specified will be the top left of the graphic. If only one x,y pair is specified, it refers to the top left.

LINE_P

LINE Syntax: `LINE(`*G, x1, y1, x2, y2, c*`)`

`LINE_P(`*G, x1, y1, x2, y2, c*`)`

Draws a line of color *c* on *G* between points *x1,y1* and *x2,y2*.

G can be any of the graphics variables and is optional. The default is *G0*.

c can be `0` to `3` (`0`=black, `1`= dark gray, `2`= light gray, `3`= white). *c* is optional. The default is black.

PIXOFF_P

PIXOFF Syntax: `PIXOFF(`[*G*], *xposition, yposition*`)`

`PIXOFF_P(`[*G*], *xposition, yposition*`)`

Sets the color of the pixel *G* with coordinates *x,y* to white. *G* can be any of the graphics variables and is optional. The default is *G0*, the current graphic

PIXON_P

PIXON Syntax: `PIXON`([*G*], *xposition, yposition* [,*color*])

`PIXON_P`([*G*], *xposition, yposition* [,*color*])

Sets the color of the pixel *G* with coordinates *x,y* to color. *G* can be any of the graphics variables and is optional. The default is *G0*, the current graphic. Color can be `0` to `3` (`0`=black, `1`= dark gray, `2`= light gray, `3`= white) and is optional. The default is `0`.

RECT_P

RECT Syntax: `RECT`([*G, x1, y1, x2, y2, edgecolor, fillcolor*])

`RECT_P`([*G, x1, y1, x2, y2, edgecolor, fillcolor*])

Draws a rectangle on G between points *x1,y1* and *x2,y2* using edgecolor for the perimeter and fillcolor for the inside.

G can be any of the graphics variables and is optional. The default is *G0*, the current graphic.

x1, y1 are optional. The default values represent the top left of the graphic.

x2, y2 are optional. The default values represent the bottom right of the graphic.

edgecolor and *fillcolor* can be `-1` to `3` (`-1`= transparent, `0`=black, `1`= dark gray, `2`= light gray, `3`= white).

edgecolor is optional. The default is white.

fillcolor is optional. The default is edgecolor.

To erase a `GROB`, execute `RECT(`*G*`)`. To clear the screen execute `RECT()`.

When optional arguments are provided in a command with multiple optional parameters (like `RECT`), the arguments provided correspond to the leftmost parameters first. For example, in the program below, the arguments `40` and `90` in the `RECT_P` command correspond to *x1* and *y1*. The argument `0` corresponds to *edgecolor*, since there is only the one additional argument. If there had been two additional arguments, they would have referred to *x2* and *y2* rather than *edgecolor* and *fillcolor*. The program produces the figure below.

```
EXPORT BOX()
BEGIN
RECT();
RECT_P(40,90,0)
;
FREEZE;
END;
```

The program below also uses the RECT_P command. In this case, the pair of arguments *0* and *3* correspond to *x2* and *y2*. The program produces the figure below to the right.

```
EXPORT BOX()
BEGIN
RECT();INVERT(G
0);
RECT_P(40,90,0,
3);
FREEZE;
END;
```

SUBGROB_P

SUBGROB Syntax: SUBGROB(*srcGRB* [,*x1, y1, x2, y2*], *trgtGRB*)

SUBGROB_P(*srcGRB* [,*x1, y1, x2, y2*], *trgtGRB*)

Sets *trgtGRB* to be a copy of the area of *srcGRB* between points *x1,y1* and *x2,y2*.

srcGRB can be any of the graphics variables and is optional. The default is *G0*.

trgtGRB can be any of the graphics variables except *G0*.

x2, y2 are optional and if not specified will be the bottom right of *srcGRB*.

x1, y1 are optional and if not specified will be the top left of *srcGRB*.

NOTE SUBGROB(*G1*, *G4*) will copy G1 in G4.

TEXTOUT_P

TEXTOUT Syntax: TEXTOUT(*text* [,*G*], *x, y* [,*font, c1, width, c2*])

`TEXTOUT_P(`*text* [,*G*], *x, y* [,*font, c1, width, c2*])

Draws text using color *c1* on graphic *G* at position *x, y* using *font*. Do not draw text more than *width* pixels wide and erase the background before drawing the text using color *c2*. *G* can be any of the graphics variables and is optional. The default is *G0*.

Font can be:

`0`: current font selected in mode screen, `1`: small font `2`: large font. Font is optional and if not specified is the current font selected in mode screen.

c1 can be `0` to `3` (`0`=black, `1`= dark gray, `2`= light gray, `3`= white). *c1* is optional. The default is black.

width is optional and if not specified, no clipping is performed.

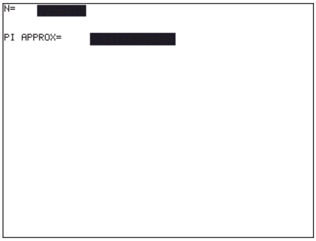
c2 can be `0` to `3` (`0`=black, `1`= dark gray, `2`= light gray, `3`= white). *c2* is optional. If not specified the background is not erased.

Example:

This program displays the successive approximations for using the series for the arctangent(1).

```
EXPORT RUNPISERIES()
BEGIN
LOCAL sign;
2 ▶ K;4 ▶A;
-1 ▶ sign;
RECT();
TEXTOUT_P("N=",0,0);
TEXTOUT_P("PI APPROX=",0,30);
REPEAT
A+sign*4/(2*K-1) ▶ A;
TEXTOUT_P(K ,35,0,2,0,100,3);
TEXTOUT_P(A ,90,30,2,0,100,3);
```

```
sign*-1 ▶
sign;
K+1▶ K;
UNTIL 0;
END;
```



The program executes until the user presses On/Off to terminate. The spaces after `K` (the number of the term) and `A` (the current approximation) in the `TEXTOUT_P` commands are there to overwrite the previously displayed value.

Matrix

Some matrix commands take as their argument the matrix variable name on which the command is applied. Valid names are the global variables M0–M9 or a local variable that contains a matrix.

ADDCOL Syntax: `ADDCOL`

(*name* [,*value1,…,valuen*],*column_number*)

Inserts values into a new column inserted before *column_number* in the specified matrix. You enter the values as a vector. (These are not optional arguments.) 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.

ADDROW Syntax: `ADDROW`

(*name* [,*value1,…,valuen*],*row_number*)

Inserts values into a new row inserted before *row_number* in the specified matrix. You enter the values as a vector. (These are not optional arguments.) 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.

DELCOL Syntax: `DELCOL(`*name* ,*column_number*)

Deletes *column column_number* from matrix name.

DELROW Syntax: `DELROW(`*name* ,*row_number*)

Deletes row *row_number* from matrix name.

EDITMAT Syntax: `EDITMAT` (*name*)

Starts the Matrix Editor and displays the specified matrix. If used in programming, returns to the program when user presses OK. Even though this command returns the matrix that was edited, `EDITMAT` cannot be used as an argument in other matrix commands.

REDIM Syntax: `REDIM` (*name, size*)

Redimensions the specified matrix (*name*) or vector to *size*. For a matrix, size is a list of two integers (*n1,n2*). For a vector, size is a list containing one integer (*n*). Existing values in the matrix are preserved. Fill values will be 0.

REPLACE Syntax: `REPLACE` (*name, start, object*)

Replaces portion of a matrix or vector stored in *name* with an *object* starting at position *start*. *Start* for a matrix is a list containing two numbers; for a vector, it is a single number. `REPLACE` also works with lists, graphics, and strings. For example, REPLACE("123456", 2, "GRM") -> "1GRM56"

SCALE Syntax: `SCALE`(*name, value, rownumber*)

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

SCALEADD Syntax: `SCALEADD`(*name, value, row1, row2*)

Multiplies the specified *row1* of the matrix (*name)* by *value*, then adds this result to the second specified *row2* of the matrix (*name)*.

SUB Syntax: `SUB`(*name, start, end*)

Extracts a sub-object—a portion of a list, matrix, or graphic—and stores it in *name*. *Start* and *end* are each specified using a list with two numbers for a matrix, a number for vector or lists, or an ordered pair, (*X,Y*), for graphics: `SUB(M1{1,2},{2,2})`

SAWAPCOL Syntax: `SWAPCOL`(*name, column1, column2*)

Swaps *column1* and *column2* of the specified matrix (*name*).

SWAPROW Syntax: `SWAPROW` (*name, row1, row2*)

Swaps *row1* and *row2* in the specified matrix (*name*).

App Functions

These commands allow you to launch any HP app, bring up any view of the current app, and change the options in the Views menu.

STARTAPP Syntax: `STARTAPP(`*"name"*`)`

Starts the app with *name*. This will cause the app program's `START` function to be run, if it is present. The app's default view will be started. Note that the `START` function is always executed when the user taps Start in the Application Library. This also works for user-defined apps.

Example: `STARTAPP(`*"Function"*`)` launches the Function app.

STARTVIEW Syntax: `STARTVIEW(`*n* [,*draw?*]`)`

Starts the *n*th view of the current app. If *draw?* is true (that is, not 0), it will force an immediate redrawing of the screen for that view.

The view numbers (*n*) are as follows:

```
Symbolic:0
Plot:1
Numeric:2
Symbolic Setup:3
Plot Setup:4
Numeric Setup:5
App Info: 6
Views Menu:7
First special view (Split Screen Plot Detail):8
Second special view (Split Screen Plot Table):9
Third special view (Autoscale):10
Fourth special view (Decimal):11
Fifth special view (Integer):12
Sixth special view (Trig):13
```

The special views in parentheses refer to the Function app, and may differ in other apps. The number of a special view corresponds to its position in the Views menu for that app. The first special view is launched by

STARTVIEW(8), the second with STARTVIEW(9), and so on.

You can also launch views that are not specific to an app by specifying a value for *n* that is less than 0:

```
HomeScreen:-1
Home Modes:-2
Memory Manager:-3
Applications Library:-4
Matrix Catalog:-5
List Catalog:-6
Program Catalog:-7
Notes Catalog:-8
```

VIEW Syntax: VIEWS ("*string*"[,*program_name*])

Adds a view to the Views menu. When *string* is selected, runs *program_name*.

Integer

BITAND Syntax: BITAND(int1, int2, … intn)

Returns the bitwise logical AND of the specified integers.

Example: BITAND(20,13) returns 4.

BITNOT Syntax: BITNOT(int)

Returns the bitwise logical NOT of the specified integer.

Example: BITNOT(47) returns 549755813840.

BITOR Syntax: BITOR(int1, int2, … intn)

Returns the bitwise logical OR of the specified integers.

Example: BITAND(9,26) returns 27.

BITSL Syntax: BITSL(int1 [,int2])

Bitwise Shift Left. Takes one or two integers as input and returns the result of shifting the bits in the first integer to the left by the number places indicated by the second integer. If there is no second integer, the bits are shifted to the left by one place,

Examples:

BITSL(28,2) returns 112

BITSL(5) returns 10.

BITSR Syntax: `BITRL(int1 [,int2])`

Bitwise Shift Right. Takes one or two integers as input and returns the result of shifting the bits in the first integer to the right by the number places indicated by the second integer. If there is no second integer, the bits are shifted to the right by one place,

Examples:

`BITSR(112,2)` returns `28`

`BITSR(10)` returns `5`.

BITXOR Syntax: `BITXOR(int1, int2, … intn)`

Returns the bitwise logical exclusive OR of the specified integers.

Example: `BITAND(9,26)` returns `19`.

B→R Syntax: `B→R(#integerm)`

Converts an integer in base *m* to a decimal integer (base 10). The base marker *m* can be *b* (for binary), *o* (for octal), or *h* (for hexadecimal).

Example: `B→R(#1101b)` returns `13`

GETBASE Syntax: `GETBASE(#integer[m])`

Returns the base for the specified integer (in whatever is the current default base): 0 = default, 1 = binary, 2 = octal, 3 = hexadecimal.

Examples: `GETBASE(#1101b)` returns `#1h` (if the default base is hexadecimal) while `GETBASE (#1101)` returns #0h.

GETBITS Syntax: `GETBITS(#integer)`

Returns the number of bits used by *integer*, expressed in the default base.

Example: `GETBITS(#22122)` returns `#20h` (if the default base is hexadecimal)

R→B Syntax: `R→B(integer)`

Converts a decimal integer (base 10) to an integer in the default base.

Example: `R→B(13)` returns `#1101b` (if the default base is binary) or #Dh (if the default base is hexadecimal).

SETBITS Syntax: `SETBITS(#integer[m] [,bits])`

Sets the number of bits to represent *integer*. Valid values are in the range –64 to 65. If *m* or *bits* is omitted, the default value is used.

Example: `SETBITS(#1111,b15)` returns `#1111b:15`

SETBASE Syntax: `SETBASE(#integer[m][c])`

Displays *integer* expressed in base *m* in whatever base is indicated by *c*, where can be 1 (for binary), 2 (for octal), or 3 (for hexadecimal). Parameter m can be b (for binary), d (for decimal), o (for octal), or h (for hexadecimal). If *m* is omitted, the input is assumed to be in the default base. Likewise, if c is omitted, the output is displayed in the default base.

Examples: `SETBASE (#34o,1)` returns `#11100b` while `GETBASE (#1101)` returns #0h ((if the default base is hexadecimal).

I/O

I/O commands are used for inputting data into a program, and for outputting data from a program. They allow users to interact with programs.

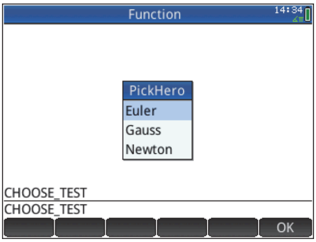
These commands start the Matrix and List editors.

CHOOSE Syntax: `CHOOSE(`*var, "title", "item1", "item2",…,"itemn"*)

Displays a choose box with the *title* and containing the choose items. If the user selects an object, the variable whose name is provided will be updated to contain the number of the selected object (an integer, 1, 2, 3, …) or 0 if the user taps Cancel.

Returns true (not zero) if the user selects an object, otherwise return false (0).

Example:




```
CHOOSE
(N,"PickHero",
"Euler","Gauss
","Newton");
IF N==1 THEN
PRINT("You
picked
Euler"); ELSE
IF N==2 THEN PRINT("You picked
```

```
Gauss");ELSE PRINT("You picked
Newton");
END;
END;
```

After execution of CHOOSE, the value of *n* will be updated to contain 0, 1, 2, or 3. The IF THEN ELSE command causes the name of the selected person to be printed to the terminal.

EDITLIST Syntax: EDITLIST(*listvar*)

Starts the List Editor loading *listvar* and displays the specified list. If used in programming, returns to the program when user taps OK.

Example: EDITLIST(*L1*) edits list L1.

EDITMAT Syntax: EDITMAT(*matrixvar*)

Starts the Matrix Editor and displays the specified matrix. If used in programming, returns to the program when user taps OK.

Example: EDITMAT(*M1*) edits matrix M1.

GETKEY Syntax: GETKEY

Returns the ID of the first key in the keyboard buffer, or –1 if no key was pressed since the last call to GETKEY. Key IDs are integers from 0 to 50, numbered from top left (key 0) to bottom right (key 50) as shown in figure 26-1.

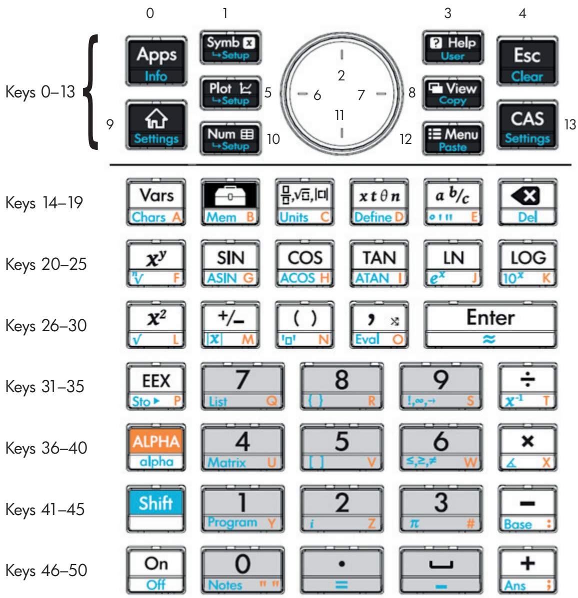


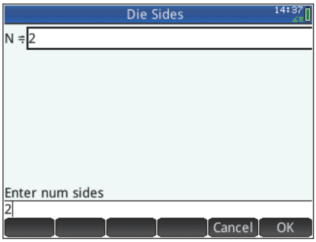
Figure 26-1: Numbers of the keys

INPUT Syntax: `INPUT(`*var* [,"*title*", "*label*", "*help*", *default*]);

Opens a dialog box with the title text *title*, with one field named *label*, displaying *help* at the bottom and using the *default value*. Updates the variable *var* if the user taps OK and returns 1. If the user taps Cancel, it does not update the variable, and returns 0.

Example:

```
EXPORT SIDES;
EXPORT
GETSIDES()
BEGIN
INPUT(SIDES,"D
ie Sides","N =
","Enter num
sides",2);
END;
```



ISKEYDOWN Syntax: `ISKEYDOWN(`*key_id*);

Returns true (non-zero) if the key whose *key_id* is provided is currently pressed, and false (0) if it is not.

MOUSE

Syntax: `MOUSE[(index)]`

Returns two lists describing the current location of each potential pointer (or empty lists if the pointers are not used). The output is {x , y, original z, original y, type} where *type* is 0 (for new), 1 (for completed), 2 (for drag), 3 (for stretch), 4 (for rotate), and 5 (for long click).

The optional parameter index is the *n*th element that would have been returned—x, y, original x, etc.—had the parameter bee omitted (or –1 if no pointer activity had occurred).

MSGBOX

Syntax: `MSGBOX`(*expression or string* [,*ok_cancel?*]);

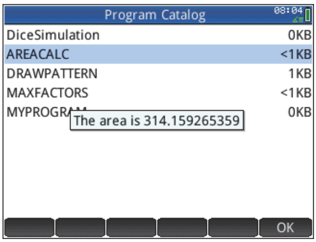
Displays a message box with the value of the given expression or *string*.

If *ok_cancel?* is true, displays the OK and Cancel buttons, otherwise only displays the OK button. Default value for *ok_cancel* is false.

Returns true (non-zero) if the user taps OK, false (0) if the user presses Cancel.

```
EXPORT AREACALC()
BEGIN
LOCAL radius;
INPUT(radius, "Radius of Circle","r =
","Enter radius",1);
MSGBOX("The area is " +π*radius^2);
END;
```

If the user enters 10 for the radius, the message box shows this:



PRINT

Syntax: `PRINT`(*expression* or *string*);

Prints the result of *expression* or *string* to the terminal.

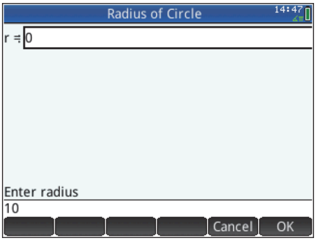
The terminal is a program text output viewing mechanism which is displayed only when `PRINT` commands are executed. When visible, you can press or to view the text, Del to erase the text and any other key to hide the terminal. Pressing On Off stops the interaction with the terminal. `PRINT` with no argument clears the terminal.

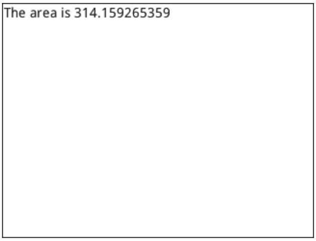
There are also commands for outputting data in the Graphics section. In particular, the commands `TEXTOUT` and `TEXTOUT_P` can be used for text output.

This example prompts the user to enter a value for the radius of a circle, and prints the area of the circle on the terminal.

```
EXPORT AREACALC()
BEGIN
LOCAL radius;
INPUT(radius,
"Radius of
Circle","r =
","Enter
radius",1);

PRINT("The
area is "
+π*radius^2);
END;
```





Notice the use of the `LOCAL` variable for the radius, and the naming convention that uses lower case letters for the local variable. Adhering to such a convention will improve the readability of your programs.

WAIT Syntax: `WAIT(`*n*`);`

Pauses program execution for *n* seconds. With no argument or with *n* = 0, pauses program execution for one minute.

More

%CHANGE Syntax: `%CHANGE(x,y)`

The percentage change in going from *x* to *y*.

Example: `%CHANGE(20,50)` returns 150.

%TOTAL Syntax: `%TOTAL(x,y)`

The percentage of *x* that is *y*.

Example: `%TOTAL(20,50)` returns 250.

CAS Syntax: `CAS(Exp.)` or `CAS.function(...)` or `CAS.variable[(...)]`

Evaluates the expression or variable using the CAS.

EVALLIST Syntax: `EVALLIST({list})`

Evaluates the content of each element in a list and returns an evaluated list.

EXECON Creates a new list based on the elements in one or more *lists* by iteratively modifying each element according to an *expression* that contains the ampersand character (&). The syntax:

EXECON(*expression* with &, *list*$_1$ *[list*$_2$*]* … *[list*$_n$*]*)

Where the expression is & plus an operator (*o*) plus a number (*n*), each element in the list is operated on by *o* and *n* and a new list created.

Examples:

`EXECON("&+1",{1,2,3})` returns `{2,3,4}`

Where the & is followed directly by a number, the position in the list is indicated. For example:

`EXECON("&2-&1",{1, 4, 3, 5}"` returns `{3, -1, 2}`

In the example above, &2 indicates the second element and &1 the first element in each pair of elements. The minus operator between them subtracts the first from the second in each pair until there are no more pairs. Note that numbers appended to & can only be from 1 to 9 inclusive.

EXECON can also operate on more than one list. For example:

`EXECON("&1+&2",{1,2,3},{4,5,6})` returns `{5,7,9}`

In the example above, &1 indicates an element in the first list and &2 indicates the corresponding element in the second list. The plus operator between them adds the two elements until there are no more pairs. Note that numbers appended to & can only be from 1 to 9 inclusive.

EXECON can also begin operating on a specified element in a specified list. For example:

`EXECON("&23+&1",{1,5,16},{4,5,6,7})` returns `{7,12}`

In the example above, &23 indicates that operations are to begin on the second list and with the third element. To that element is added the first element in the first list. The process continues until there are no more pairs.

Again, the digits appended to & can only be from 1 to 9 inclusive.

→HMS Syntax: `→HMS(value)`

Converts a decimal *value* to hexagesimal format; that is, in units subdivided into groups of 60. This includes degrees, minutes, and seconds as well as hours, minutes, and seconds.

Example: `→HMS(54.8763)` returns `54°52′34.68″`

HMS→ Syntax: `HMS→(value)`

Converts a *value* expressed hexagesimal format to decimal format.

Example: `HMS→(54°52′34.68″)` returns `54.8763`

ITERATE Syntax: `ITERATE(expr, var, ivalue, #times)`

For *#times*, repeatedly evaluate *expr* in terms of *var* beginning with *var* = *ivalue*.

Example: `ITERATE(X^2, X, 2, 3)` returns `256`

TICKS Syntax: TICKS

Returns the internal clock value in milliseconds.

TIME Syntax: `TIME`(*program_name*)

Returns the time in milliseconds required to execute the program *program_name*. The results are stored in the variable `TIME`. The variable `TICKS` is similar. It contains the number of milliseconds since boot up.

Variables and Programs

The HP Prime has four types of variables: Home variables, App variables, CAS variables, and User variables. You can retrieve these variables from the Variable menu (Vars).

Home variables are used for real numbers, complex numbers, graphics, lists, and matrices among other things. Home variables keep the same value in Home and in apps.

App variables are those whose values depend on the current app. The app variables are used in programming to represent the definitions and settings you make when working with apps interactively.

CAS variables are exactly the same as Home variables except that they are used only when doing CAS operations. They can, however, be called by commands in Home view. The names for CAS variables mirror those for Home variables except that they must be lowercase.

User variables are variables created by the user or exported from a user program. They provide one of several mechanisms to allow programs to communicate with the rest of the calculator, and with other programs. Once a variable has been exported from a program, it will appear among the User variables in the Variables menu, next to the program that exported it.

This chapter deals with App variables and User variables. For information on Home and CAS variables, see chapter 21, “Variables”, beginning on page 373.

App variables

Not all app variables are used in every app. S1Fit, for example, is only used in the Statistics 2Var app. However, most of the variables are used in common by the Function app, the Parametric app, the Polar app, the Sequence app, the Solve app, the Statistics 1Var app, the Statistics 2Var app, and others. If a variable is not available in all of these apps, or is available only in some other apps, then a list of the apps where the variable can be used appears under the variable name.

The following sections list the app variables by the view in which they are used. To see the variables listed by the menus in which they appears on the Variables menu see “App variables”, beginning on page 378.

Plot view variables

Axes

Turns axes on or off.

In Plot Setup view, check (or uncheck) `AXES`.

In a program, type:

`0` ▶ `Axes`—to turn axes on.

`1` ▶ `Axes`—to turn axes off.

Cursor

Sets the type of cursor. (Inverted or blinking is useful if the background is solid).

In Plot Setup view, choose `Cursor`.

In a program, type:

`0` ▶ `CrossType`—for solid crosshairs (default).

`1` ▶ `CrossType`—to invert the crosshairs.

`2` ▶ `CrossType`—for blinking crosshairs.

GridDots

Turns the background dot grid in Plot view on or off.

In Plot Setup view, check (or uncheck) `GRID DOTS`.

In a program, type:

`0` ▶ `GridDots`—to turn the grid dots on (default).

`1` ▶ `GridDots`—to turn the grid dots off.

GridLines

Turns the background line grid in Plot View on or off.

In Plot Setup View, check (or uncheck) `GRID LINES`.

In a program, type:

`0` ▶ `GridLines`—to turn the grid lines on (default).

`1` ▶ `GridLines`—to turn the grid lines off.

Hmin/Hmax
Statistics 1Var

Defines the minimum and maximum values for histogram bars.

In Plot Setup View for one-variable statistics, set values for `HRNG`.

In a program, type:

n_1 ▶ `Hmin`

n_2 ▶ `Hmax`

where $n_1 < n_2$

Hwidth
Statistics 1Var

Sets the width of histogram bars.

In Plot Setup View for one-variable statistics, set a value for `Hwidth`.

In a program, type:

n ▶ `Hwidth`

Labels

Draws labels in Plot View showing X and Y ranges.

In Plot Setup View, check (or uncheck) `Labels`.

In a program, type:

`1` ▶ `Labels`—to turn labels on (default)

`0` ▶ `Labels`—to turn labels off.

Method

Defines the graphing method: adaptive, fixed-step segments, or fixed-step dots. (See "Graphing methods" on page 89 for an explanation of the difference between these methods.)

In a program, type:

`0` ▶ `Method`—select adaptive

`1` ▶ `Method`—select fixed-step segments

`2` ▶ `Method`—select fixed-step dots

Nmin/Nmax
Sequence

Defines the minimum and maximum values for the independent variable.

Appears as the `NRNG` fields in the Plot Setup view. In Plot Setup View, enter values for `NRNG`.

In a program, type:

n_1 ▶ `Nmin`

n_2 ▶ `Nmax`

where $n_1 < n_2$

Recenter

Recenters at the cursor when zooming.

From Plot-Zoom-Set Factors, check (or uncheck) `Recenter`.

In a program, type:

0 ▶ `Recenter`— to turn recenter on (default).

1 ▶ `Recenter`— to turn recenter off.

S1mark-S5mark
Statistics 2Var

Sets the mark to use for scatter plots.

In Plot Setup view for two-variable statistics, select one of `S1mark-S5marks`.

In a program, type:

?????

SeqPlot
Sequence

Enables you to choose between a Stairstep or a Cobweb plot.

In Plot Setup view, select `SeqPlot`, then choose `Stairstep` or `Cobweb`.

In a program, type:

0 ▶ `SeqPlot`—for Stairstep.

1 ▶ `SeqPlot`—for Cobweb.

θmin/θmax
Polar

Sets the minimum and maximum independent values.

In Plot Setup, View enter values for `RNG`.

In a program, type:

n_1 ▶ `θmin`

n_2 ▶ `θmax`

where $n_1 < n_2$

θstep
Polar

Sets the step size for the independent variable.

In Plot Setup view, enter a value for `STEP`.

In a program, type:

n ▶ `θstep`

where $n > 0$

Tmin/Tmax
Parametric

Sets the minimum and maximum independent variable values.

In Plot Setup View, enter values for `TRNG`.

In a program, type:

n_1 ▶ `Tmin`

n_2 ▶ `Tmax`

where $n_1 < n_2$

Tstep
Parametric

Sets the step size for the independent variable.

In Plot Setup View, enter a value for `TSTEP`.

In a program, type

n ▶ `Tstep`

where $n > 0$

Xtick

Sets the distance between tick marks for the horizontal axis.

In Plot Setup View, enter a value for `Xtick`.

I a program, type:

n ▶ `Xtick` where $n > 0$

Ytick

Sets the distance between tick marks on the vertical axis.

In Plot Setup View, enter a value for `Ytick`.

In a program, type:

n ▶ `Ytick` where $n > 0$

Xmin/Xmax

Sets the minimum and maximum horizontal values of the plot screen.

In Plot Setup View, enter values for `XRNG`.

In a program, type:

n_1 ▶ `Xmin`

n_2 ▶ `Xmax`

where $n_1 < n_2$

Ymin/Ymax

Sets the minimum and maximum vertical values of the plot screen.

In Plot Setup View, enter the values for `YRNG`.

In a program, type:

n_1 ▶ `Ymin`

n_2 ▶ `Ymax`

where $n_1 < n_2$

Xzoom

Sets the horizontal zoom factor.

In Plot View, press MENU then ZOOM. Scroll to `Set Factors`, select it and press OK. Enter the value for `X Zoom` OK.

In a program, type:

n ▶ `Xzoom`

where $n > 0$

The default value is 4.

Yzoom

From Plot setup (Plot Setup), press MENU then ZOOM. Scroll to `Set Factors`, select it and press OK. Enter the value for `Y zoom` and press OK.

Or, in a program, type:

n ▶ `Yzoom`

The default value is 4.

Symbolic view variables

AltHyp
Inference

Determines the alternative hypothesis used for a hypothesis testing. Choose an option from the Symbolic view.

In a program, type:

`0` ▶ `AltHyp`—for $\mu < \mu_0$

`1` ▶ `AltHyp`—for $\mu > \mu_0$

`2` ▶ `AltHyp`—for $\mu \neq \mu_0$

E0...E9
Solve

Can contain any equation or expression. Independent variable is selected by highlighting it in Numeric View.

Example:

`X+Y*X-2=Y`▶ `E1`

F0...F9
Function

Can contain any expression. Independent variable is `X`.

Example:

`SIN(X)`▶ `F1`

H1...H5
Statistics 1Var

Contains the data values for a 1-variable statistical analysis. For example, H1(n) returns the nth value in the data set for the H1 analysis.

H1Type...H5Type
Statistics 1Var

Sets the type of plot used to graphically represent the statistical analyses H1 through H5. From the Symbolic setup, specify the type of plot in the field for Type1, Type 2, etc.

Or in a program, store one of the following constant integers or names into the variables `H1Type, H2Type`, etc.

`0 Histogram` (default)

1 Box and Whisker

2 Normal Probability

3 Line

4 Bar

5 Pareto

Example:

```
2▶H3Type
```

Method
Inference

Determines whether the Inference app is set to calculate hypothesis test results or confidence intervals.

In a program, type:

`0 ▶ Method`—for `Hypothesis Test`

`1 ▶ Method`—for `Confidence Interval`

R0...R9
Polar

Can contain any expression. Independent variable is θ.

Example:

```
2*SIN(2*θ)▶ R1
```

S1...S5
Statistics 2Var

Contains the data values for a 2-variable statistical analysis. For example, S1(n) returns the nth data pair in the data set for the S1 analysis. With no argument, returns a list containing the independent column name, the dependent column name and the number of the fit type.

S1Type...S5Type
Statistics 2Var

Sets the type of fit to be used by the `FIT` operation in drawing the regression line. From Symbolic Setup view, specify the fit in the field for `Type1`,`Type2`, etc.

In a program, store one of the following constant integers or names into a variable `S1Type`,`S2Type`, etc.

0 Linear

1 Logarithmic

2 Exponential

3 Power

4 Exponent

5 Inverse

6 Logistic

7 Quadratic

8 Cubic

9 Quartic

10 User Defined

Example:

```
Cubic ▶ S2type
```

or

```
8 ▶ S2type
```

Type
Inference

Determines the type of hypothesis test or confidence interval. Depends upon the value of the variable `Method`. Make a selection from the Symbolic view.

Or, in a program, store the constant number from the list below into the variable Type. With `Method=0`, the constant values and their meanings are as follows:

0 Z-Test:1 μ

1 Z-Test: $\mu_1 - \mu_2$

2 Z-Test:1 π

3 Z-Test: $\pi_1 - \pi_2$

4 T-Test:1 μ

5 T-Test: $\mu_1 - \mu_2$

With `Method=1`, the constants and their meanings are:

0 Z-Int:1 μ

1 Z-Int: $\mu_1 - \mu_2$

2 Z-Int:1 π

3 Z-Int: $\pi_1 - \pi_2$

4 T-Int:1 μ

5 T-Int: $\mu_1 - \mu_2$

X0, Y0…X9,Y9
Parametric

Can contain any expression. Independent variable is T.

Example:

```
SIN(4*T)▶Y1;2*SIN(6*T)▶X1
```

U0…U9
Sequence

Can contain any expression. Independent variable is N.

Example:

```
RECURSE (U,U(N-1)*N,1,2) ▶U1
```

Numeric view variables

C0…C9
Statistics 2Var

C0 through C9, for columns of data. Can contain lists.

Enter data in the Numeric view.

In a program, type:

```
LIST▶Cn
```

where $n = 0$, 1, 2, 3 … 9 and `LIST` is either a list or the name of a list.

D0…D9
Statistics 1Var

D0 through D9, for columns of data. Can contain lists.

Enter data in the Numeric view.

In a program, type:

```
LIST▶Dn
```

where $n = 0$, 1, 2, 3 … 9 and `LIST` is either a list or the name of a list.

NumIndep
Function
Parametric
Polar
Sequence

Specifies the list of independent values to be used by `Build Your Own Table`. Enter your values one-by-one in the Numeric view.

In a program, type:

`LIST ▶ NumIndep`

`List` can be either a list itself or the name of a list.

NumStart
Function
Parametric
Polar
Sequence

Sets the starting value for a table in Numeric view.

From Numeric Setup view, enter a value for `NUMSTART`.

In a program, type:

n ▶ `NumStart`

NumStep
Function
Parametric
Polar
Sequence

Sets the step size (increment value) for an independent variable in Numeric view.

From Numeric Setup view, enter a value for `NUMSTEP`.

In a program, type:

n ▶ `NumStep`

where $n > 0$

NumType
Function
Parametric
Polar
Sequence

Sets the table format.

From Numeric Setup view, enter `0` or `1`.

In a program, type:

`0 ▶ NumType`—for `Automatic` (default).

`1 ▶ NumType`—for `BuildYourOwn`.

NumZoom
Function
Parametric
Polar
Sequence

Sets the zoom factor in the Numeric view.

From Numeric Setup view, type in a value for `NUMZOOM`.

In a program, type:

n ▶ `NumZoom`

where $n > 0$

Inference app variables

The following variables are used by the Inference app. They correspond to fields in the Inference app Numeric view. The set of variables shown in this view depends on the hypothesis test or the confidence interval selected in the Symbolic view.

Alpha

Sets the alpha level for the hypothesis test. From the Numeric view, set the value of `Alpha`.

In a program, type:

n ▶ `Alpha`

where $0 < n < 1$

Conf

Sets the confidence level for the confidence interval. From the Numeric view, set the value of `Conf`.

In a program, type:

n ▶ `Conf`

where $0 < n < 1$

Mean1

Sets the value of the mean of a sample for a 1-mean hypothesis test or confidence interval. For a 2-mean test or interval, sets the value of the mean of the first sample. From the Numeric view, set the value of `Mean1`.

In a program, type:

n ▶ `Mean1`

Mean2

For a 2-mean test or interval, sets the value of the mean of the second sample. From the Numeric view, set the value of `Mean2`.

In a program, type:

n ▶ `Mean2`

The following variables are used to set up hypothesis test or confidence interval calculations in the Inference app.

$\mu 0$

Sets the assumed value of the population mean for a hypothesis test. From the Numeric view, set the value of $\mu 0$.

In a program, type:

n ▶ $\mu 0$

where $0 < \mu 0 < 1$

n1

Sets the size of the sample for a hypothesis test or confidence interval. For a test or interval involving the difference of two means or two proportions, sets the size of the first sample. From the Numeric view, set the value of `n1`.

In a program, type:

n ▶ `n1`

n2

For a test or interval involving the difference of two means or two proportions, sets the size of the second sample. From the Numeric view, set the value of `n2`.

In a program, type:

n ▶ `n2`

$\pi 0$

Sets the assumed proportion of successes for the One-proportion Z-test. From the Numeric view, set the value of $\pi 0$.

In a program, type:

n ▶ $\pi 0$

where $0 < \pi 0 < 1$

Pooled

Determine whether or not the samples are pooled for tests or intervals using the Student's T-distribution involving two means. From the Numeric view, set the value of `Pooled`.

In a program, type:

`0` ▶ `Pooled`—for not pooled (default).

`1` ▶ `Pooled`—for pooled.

s1

Sets the sample standard deviation for a hypothesis test or confidence interval. For a test or interval involving the difference of two means or two proportions, sets the sample standard deviation of the first sample. From the Numeric view, set the value of `s1`.

In a program, type:

n ▶ `s1`

s2

For a test or interval involving the difference of two means or two proportions, sets the sample standard deviation of the second sample. From the Numeric view, set the value of `s2`.

In a program, type:

n ▶ `s2`

σ1

Sets the population standard deviation for a hypothesis test or confidence interval. For a test or interval involving the difference of two means or two proportions, sets the population standard deviation of the first sample. From the Numeric view, set the value of σ1.

In a program, type:

n ▶σ1

σ2

For a test or interval involving the difference of two means or two proportions, sets the population standard deviation of the second sample. From the Numeric view, set the value of σ2.

In a program, type:

n ▶σ2

x1

Sets the number of successes for a one-proportion hypothesis test or confidence interval. For a test or interval involving the difference of two proportions, sets the number of successes of the first sample. From the Numeric view, set the value of x1.

In a program, type:

n ▶x1

x2

For a test or interval involving the difference of two proportions, sets the number of successes of the second sample. From the Numeric view, set the value of x2.

In a program, type:

n ▶x2

Finance app variables

The following variables are used by the Finance app. They correspond to the fields in the Finance app Numeric view.

CPYR

Compounding periods per year. Sets the number of compounding periods per year for a cash flow calculation. From the Numeric view of the Finance app, enter a value for C/YR.

In a program, type:

n ▶CPYR

where $n > 0$

END

Determines whether interest is compounded at the beginning or end of the compounding period. From the Numeric view of the Finance app. Check or uncheck `END`.

In a program, type:

`1▶END`—for compounding at the end of the period (Default)

`0▶END`—for compounding at the beginning of the period

FV

Future value. Sets the future value of an investment. From the Numeric view of the Finance app, enter a value for `FV`.

In a program, type:

n ▶`FV`

Note: positive values represent return on an investment or loan.

IPYR

Interest per year. Sets the annual interest rate for a cash flow. From the Numeric view of the Finance app, enter a value for `I%YR`.

In a program, type:

n ▶`IPYR`

where $n > 0$

NbPmt

Number of payments. Sets the number of payments for a cash flow. From the Numeric view of the Finance app, enter a value for `N`.

In a program, type:

n ▶`NbPmt`

where $n > 0$

PMT

Payment value. Sets the value of each payment in a cash flow. From the Numeric view of the Finance app, enter a value for `PMT`.

In a program, type:

n ▶`PMT`

Note that payment values are negative if you are making the payment and positive if you are receiving the payment.

PPYR

Payments per year. Sets the number of payments made per year for a cash flow calculation. From the Numeric view of the Finance app, enter a value for `P/YR`.

In a program, type:

n ▶`PPYR`

where $n > 0$

PV

Present value. Sets the present value of an investment. From the Numeric view of the Finance app, enter a value for `PV`.

In a program, type:

n ▶`PV`

Note: negative values represent an investment or loan.

GSize

Group size. Sets the size of each group for the amortization table. From the Numeric view of the Finance app, enter a value for `Group Size`.

In a program, type:

n ▶`GSize`

Linear Solver app variables

The following variables are used by the Linear Solver app. They correspond to the fields in the app's Numeric view.

LSystem

Contains a 2x3 or 3x4 matrix which represents a 2x2 or 3x3 linear system. From the Numeric view of the Linear Solver app, enter the coefficients and constants of the linear system.

In a program, type:

`matrix▶LSystem`

where `matrix` is either a matrix or the name of one of the matrix variables M0-M9.

Size

Contains the size of the linear system. From the Numeric view of the Linear Solver app, press 2X2 or 3X3.

In a program, type:

`2▶Size`—for a 2x2 linear system

`3▶Size`—for a 3x3 linear system

Triangle Solver app variables

The following variables are used by the Triangle Solver app. They correspond to the fields in the app's Numeric view.

SideA

The length of Side A. Sets the length of the side opposite the angle A. From the Triangle Solver Numeric view, enter a positive value for A.

In a program, type:

n ▶`SideA`

where $n > 0$

SideB

The length of Side B. Sets the length of the side opposite the angle B. From the Triangle Solver Numeric view, enter a positive value for B.

In a program, type:

n ▶`SideB`

where $n > 0$

SideC

The length of Side C. Sets the length of the side opposite the angle C. From the Triangle Solver Numeric view, enter a positive value for C.

In a program, type:

n ▶`SideC`

where $n > 0$

AngleA

The measure of angle α. Sets the measure of angle α. The value of this variable will be interpreted according to the angle mode setting (`Degrees` or `Radians`). From the Triangle Solver Numeric view, enter a positive value for angle α

In a program, type:

n ▶`AngleA`

where $n > 0$

AngleB

The measure of angle β. Sets the measure of angle β. The value of this variable will be interpreted according to the angle mode setting (`Degrees` or `Radians`). From the Triangle Solver Numeric view, enter a positive value for angle β.

In a program, type:

n ▶AngleB

where $n > 0$

AngleC

The measure of angle δ . Sets the measure of angle δ . The value of this variable will be interpreted according to the angle mode setting (`Degrees` or `Radians`). From the Triangle Solver Numeric view, enter a positive value for angle δ .

In a program, type:

n ▶AngleC

where $n > 0$

RECT

Corresponds to the status of Rect in the Numeric view of the Triangle Solver app. Determines whether a general triangle solver or a right triangle solver is used. From the Triangle Solver view, tap Rect.

In a program, type:

`0▶RECT`—for the general Triangle Solver

`1▶RECT`—for the right Triangle Solver

Modes variables

The following variables are found in the Home Modes input form. They can all be over-written in an app's Symbolic setup.

Ans

Contains the last result calculated in the Home view.

HAngle

Sets the angle format for the Home view. From Modes view, choose `Degrees` or `Radians` for angle measure. In a program, type:

`0 ▶ HAngle`—for Degrees.

`1 ▶ HAngle`—for Radians.

HDigits

Sets the number of digits for a number format other than Standard in the Home view. From the Modes view, enter a value in the second field of Number Format.

In a program, type:

n ▶ `HDigits`, where $0 < n < 11$.

HFormat

Sets the number display format used in the Home view. From the Modes view, choose `Standard`, `Fixed`, `Scientific`, or `Engineering` in the `Number Format` field.

In a program, store one of the following the constant numbers (or its name) into the variable `HFormat`:

0 Standard

1 Fixed

2 Scientific

3 Engineering

HComplex

Sets the complex number mode for the Home view. From Modes, check or uncheck the `Complex` field. Or, in a program, type:

`0 ▶ HComplex`—for OFF.

`1 ▶ HComplex`—for ON.

Date

Returns the system date. The format is YYYY.MMDD. This format is used irrespective of the format set on the **Home Settings** screen.

Time

Returns the system time or sets the system time.

HHMMSS ▶ `Time`

Language

Sets the language. From Modes, choose a language for the `Language` field.

In a program, store one of the following constant numbers into the variable Language:

1 ▶ `Language` (English)

2 ▶ `Language` (Chinese)

3 ▶ `Language` (French)

4 ▶ `Language` (German)

5 ▶ `Language` (Spanish)

6 ▶ `Language` (Dutch)

7 ▶ `Language` (Portuguese)

Entry

Sets the entry mode. In a program, enter:

`0 ▶ Entry`—for Textbook

1 ▶ `Entry`—for Algebraic

2 ▶ `Entry`—for RPN

Integer

Base

Returns or sets the integer base. In a program, enter:

0 ▶ `Base`—for Binary

1 ▶ `Base`—for Octal

2 ▶ `Base`—for Decimal

3 ▶ `Base`—for Hexadecimal

Bits

Returns or sets the number of bits for representing integers. In a program, enter:

n ▶ `Bits` where *n* is the number of bits.

Signed

Returns or sets a flag indicating that the integer wordsize is signed or not. In a program, enter:

0 ▶ `Signed`—for unsigned

1 ▶ `Signed`—for signed

The following variables are found in the Symbolic setup of an app. They can be used to overwrite the value of the corresponding variable in Home Modes.

AAngle

Sets the angle mode.

From Symbolic setup, choose `System`, `Degrees`, or `Radians` for angle measure. `System` (default) will force the angle measure to agree with that in Modes.

In a program, type:

0 ▶ `AAngle`—for System (default).

1 ▶ `AAngle`—for Degrees.

2 ▶ `AAngle`—for Radians.

AComplex

Sets the complex number mode.

From Symbolic setup, choose `System`, `ON`, or `OFF`. System (default) will force this setting to agree with the corresponding setting in Home Modes.

In a program, type:

0 ▶ `AComplex`—for System (default).

1 ▶ `AComplex`—for ON.

2 ▶ `AComplex`—for OFF.

ADigits

Defines the number of decimal places to use for the `Fixed` number format in the app's Symbolic Setup. Affects results in the Home view.

From Symbolic setup, enter a value in the second field of `Number Format`.

In a program, type:

n ▶ `ADigits`

where $0 < n < 11$

AFormat

Defines the number display format used for number display in the Home view and to label axes in the Plot view.

From Symbolic setup, choose `Standard`, `Fixed`, `Scientific`, or `Engineering` in the Number Format field.

In a program, store the constant number (or its name) into the variable `AFormat`.

0 System

1 Standard

2 Fixed

3 Scientific

4 Engineering

Example:

`Scientific` ▶ `AFormat`

or

3 ▶ `AFormat`

Results variables

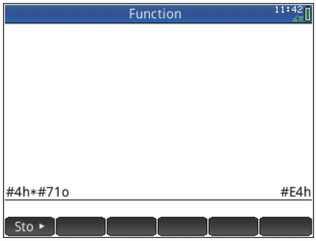
The Function, Linear Solver, Statistics 1Var, Statistics 2Var, and Inference apps offer functions that generate results that can be re-used outside those apps (such as in a program). For example, the Function app can find a root of a function, and that root is written to a variable called `Root`. That variable can then be used elsewhere.

The results variables are listed with the apps that generate them. See “App variables” on page 378.

27

Integer arithmetic

The common number base used in contemporary mathematics is base 10. By default, all calculations performed by the HP Prime are carried out in base 10, and all results are displayed in base 10.



However, the HP Prime enables you to carry out integer arithmetic in four bases: decimal (base 10), binary, (base 2), octal (base 8), and hexadecimal (base 16). For example, you could multiply 4 in base 16 by 71 in base 8 and the answer is E4 in base 16. This is equivalent in base 10 to multiplying 4 by 57 to get 228.

You indicate that you are about to engage in integer arithmetic by preceding the number with the pound symbol (#, got by pressing ALPHA 3). You indicate what base to use for the number by appending to the appropriate base marker:

Base marker	**Base**
[blank]	Adopt the defualt base (see "The default base" on page 514)
d	decimal
b	binary
o	octal
h	hexadecimal

Thus `#11b` represents 3_{10}. The base marker *b* indicates that the number is to interpreted as a binary number: 11_2. Likewise #E4h represents 228_{10}. In this case, the base marker *h* indicates that the number is to interpreted as a hexadecimal number: $E4_{16}$.

Note that with integer arithmetic, the result of any calculation that would return a remainder in floating-point arithmetic is truncated: only the integer portion is presented. Thus #100b/#10b gives the correct answer: #10b (since $4_{10}/2_{10}$ is 2_{10}). However, #100b/#11b gives just the integer component of the correct result: #1b.

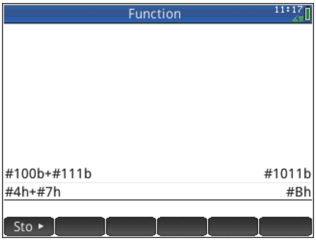
Note too that the accuracy of integer arithmetic can be limited by the integer wordsize. The wordsize is the maximum number of bits that can represent an integer. You can set this to any value between 1 and 64. The smaller the wordsize, the smaller the integer that can be accurately represented. The default wordsize is 32, which is adequate for representing integers up to approximately 2×10^9. However, integers larger than that would be truncated, that is, the most significant bits (that is, the leading bits) would be dropped. thus the result of any calculation involving such a number would not be accurate.

The default base

Setting a default base only affects the entry and display of numbers being used in integer arithmetic. If you set the default base to binary, 27 and 44 will still be represented that way in Home view, and result of those numbers being added will still be represented as 71. However, if you entered #27b, you would get a syntax error, as 2 and 7 are not integers found in binary arithmetic. You would have to enter 27 as #11011b (since $27_{10}=11011_2$).

Setting a default base means that you do not always have to specify a base marker for numbers when doing integer arithmetic. The exception is if you want to include a number from the non-default base: it will have to include the base marker. Thus if your default base is 2 and you want to enter 27 for an integer arithmetic operation, you could enter just #11011 without the *b* suffix. But if you wanted to enter $E4_{16}$, you need to enter it with the suffix: #E4h. (The HP Prime adds any omitted base markers when the calculation is displayed in history.)

Note that if you change the default base, any calculation in history that involves integer arithmetic *for which you did not explicitly add a base marker* will be resisplayed in the new base. In the example at the right, the first calculation explicitly included base markers (*b* for each operand). The second calculation was a copy of the first but without the base markers. The default base was then changed to hex. The first calculation remained as it was, while the second—without base markers being explicitly added to the operands—was redisplayed in base 16.



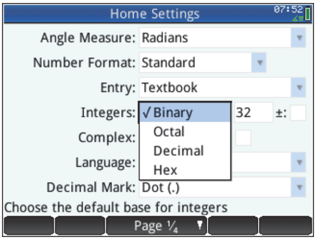
Changing the default base

The calculator's default base for integer arithmetic is 16 (hexadecimal). To change the default base:

1. Display the **Home Settings** screen:

   Shift Settings

2. Choose the base you want from the **Integers** menu: `Binary`, `Octal`, `Decimal` or `Hex`.



3. The field to the right of Integers is the wordsize field. This is the maximum number of bits that can represent an integer. The default value is 32, but you can change it any value between 1 and 64.

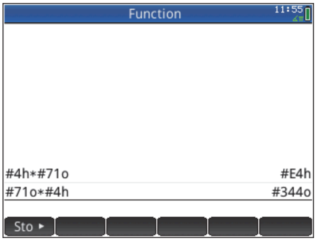
4. If you want to allow for signed integers, select the **±** option to the right of the wordsize field. Choosing this option reduces the maximum size of an integer to one bit less than the wordsize.

Examples of integer arithmetic

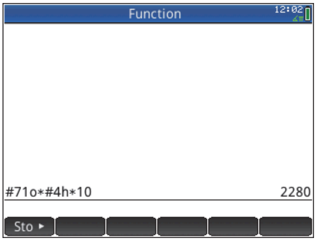
The operands in integer arithmetic can be of the same base or of mixed bases.

Integer calculation	Decimal equivalent
#10000b+#10100b = #1100b	8 + 20 = 28
#71o–#10100b = #45o	57 – 20 = 37
#4Dh * #11101b = #8B9h	77 × 29 = 2233
#32Ah/#5o = #A2h	810/5 = 162

Mixed-base arithmetic



With one exception, where you have operands of different bases, the result of the calculation is presented in the base of the first operand. The example at the right shows two equivalent calculations: the first multiplies 4_{10} by 57_{10} and the second multiplies 57_{10} by 4_{10}. Obviously the results too are mathematically equivalent. However, each is presented in the base of the operand entered first: 16 in the first case and 8 in the second.



The exception is if an operand is not marked as an integer by preceding it with #. In these cases, the result is presented in base 10.

Integer arithmetic in the CAS

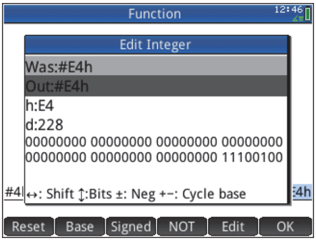
You can perform integer arithmetic in the CAS. However, the result is always displayed in base 10 (and the operands are converted to base 10). [This seems odd. If everything is converted to base 10, why is there an integer-base setting in the CAS settings? And why is binary missing as an option in the CAS settings?]

Integer manipulation

The result of integer arithmetic can be further analysed, and manipulated, by viewing it in the **Edit Integer** dialog.

1. In Home view, use the cursor keys to select the result of interest.
2. Press Shift Base (Base).

   The **Edit Integer** dialog appears. The **Was** field at the top shows the result you selected in Home view.

   The hex and decimal equivalents are shown under the **Out** field, followed by a bit-by-bit representation of the integer.

   Symbols beneath the bit representation show the keys you can press to edit the integer. (Note that this doesn't change the result of the calculation in Home view.) The keys are:

   – ◀ or ▶ (Shift): these keys shift the bits one space to the left (or right). With each press, the new integer represented appears in the **Out** field (and in the hex and decimal fields below it).

   – ▲ or ▼ (Bits): these keys increase (or decrease) the wordsize. The new wordsize is appended to the value shown in the **Out** field.

   – +/− (Neg): returns the two's complement (that is, each bit in the specified wordsize is inverted and one is added. The new integer represented appears in the **Out** field (and in the hex and decimal fields below it).

   – + or − (Cycle base): displays the integer in the **Out** field in another base.

   Menu buttons provide some additional options:

   Reset: returns all changes to their original state

Base: cycles through the bases; same as pressing +

Signed: toggles the wordsize between signed and unsigned

NOT: returns the one's complement (that is, each bit in the specified wordsize is inverted: a 0 is replaced by 1 and a 1 by 0. The new integer represented appears in the **Out** field (and in the hex and decimal fields below it).

Edit: activates edit mode. A cursor appear sand you can move abut the dialog using the cursor keys. The hex and decimal fields can be modified, as can the bit representation. A change in one such field automatically modifies the other fields.

OK: closes the dialog and saves your changes. If you don't want to save your changes, press Esc instead.

3. Make whatever changes you want.
4. To save your changes, tap OK; otherwise press Esc.

Note If you save changes, the next time you select that same result in Home view and open the **Edit Integer** dialog, the value shown in the **Was** field will be the value you saved, not the value of the result.

Base functions

Numerous functions related to integer arithmetic can be invoked from Home view, CAS view, and within programs:

- BITAND
- BITNOT
- BITOR
- BITSL
- BITSR
- BITXOR
- B→R
- GETBASE
- GETBITS
- R→B
- SETBASE
- SETBITS

These are described in "Integer", beginning on page 483.

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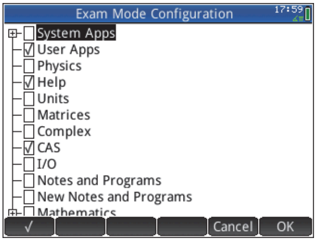
Limiting functionality



Certain functions of the calculator can be disabled for a set period, with the disabling controlled by a password. This feature will primarily be of interest to teachers, proctors, and invigilators who want to ensure that the calculator is used appropriately by students sitting an examination. In the illustration above, user-customized apps, the help system and the computer algebra system have been selected for disabling.

The settings, and a list of the functions that can be disabled, are accessible from the **Home Settings** screen. When you disable functions, you put the calculator into *exam mode*.

Before initiating exam mode, you can choose to activate a light on the calculator that will flash periodically during exam mode. The light is on the top edge of the calculator. The light will help the supervisor of the examination detect if any particular calculator has dropped out of exam mode. (The flashing of lights on all calculators placed in exam mode will be synchronised so that all will flash at the same time.)

Exam configurations

A particular set of enabled and disabled functions is called an *exam mode configuration*. You can create a default exam mode configuration. You can also create any number of additional configurations (each with a name of your choosing).

A configuration named `Default Exam` appears when you first access the **Exam Mode** screen. This configuration has no functions disabled. If only one configuration is needed, you can simply modify the default exam configuration. If you envisage the need for a number of configurations—different ones for different examinations, for example—modify the default configuration so that it matches the settings you will most often need, and then create other configurations for the settings you will need less often.

There are two ways to access the screen for configuring and activating exam mode:

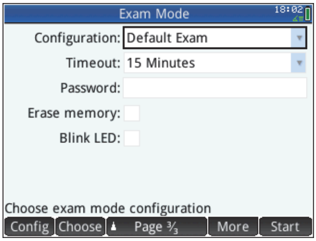
- press On + ALPHA + a b/c
- choose the third page of the **Home Settings** screen.

The procedure below illustrates the second method.

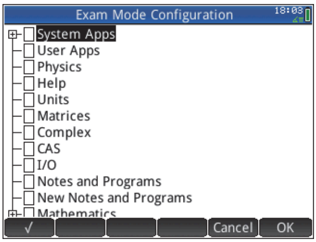
Modifying the default configuration

1. Press Shift Settings. The **Home Settings** screen appears.
2. Tap Page 1/4.
3. Tap Page 2/4.

   The **Exam Mode** screen appears. You use this screen to activate a particular configuration (just before an examination begins, for example).



4. Tap Config. The **Exam Mode Configuration** screen appears.



5. Select those functions you want disabled, and make sure that those functions you don't want disabled are not selected.

An expand box at the left of a function indicates that there are sub-functions that you can individually disable. (Notice that there is an expand box beside `System Apps` in the example shown above.) Tap on the expand box to see the sub-functions. You can then select the sub-functions individually. If you want to disable all the sub-functions, just select the top-level function.

You can select (or deselect) an option either by tapping on the check box beside it, or by using the cursor keys to scroll to it and tapping √.

6. When you have finished selecting the functions to be disabled, tap OK.

   If you want to activate exam mode now, continue with "Activating Exam Mode" below.

To return to the default configuration

1. Press Shift Settings. The **Home Settings screen** appears.
2. Tap Page 1/4.
3. Tap Page 2/4.

   The **Exam Mode** screen appears.
4. Choose `Default Exam` from the **Configuration** list.
5. Tap More, select `Reset` from the menu and tap OK to confirm your intention to return the configuration to its default settings.

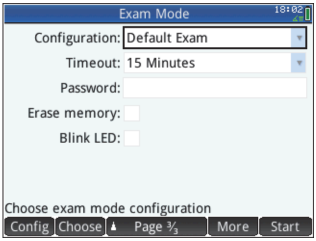
Creating a new configuration

You can modify the default exam configuration when new circumstances require a different set of disabled functions. Alternatively, you can retain the default configuration and create a new configuration. When you create a new configuration, you choose an existing configuration on which to base it.

1. Press Shift Settings. The **Home Settings screen** appears.

2. Tap Page ¼.
3. Tap Page ²⁄₄.

   The **Exam Mode** screen appears.



4. Choose a base configuration from the **Configuration** list. If you have not created any exam mode configurations before, the only base configuration will be `Default Exam`.
5. Tap More, select `Copy` from the menu and enter a name for the new configuration.

   See “Adding text” on page 20 if you need help with entering alphabetic characters.
6. Tap OK twice.
7. Tap Config. The **Exam Mode Configuration** screen appears.
8. Select those functions you want disabled, and make sure that those functions you don’t want disabled are not selected.
9. When you have finished selecting the functions to be disabled, tap OK.

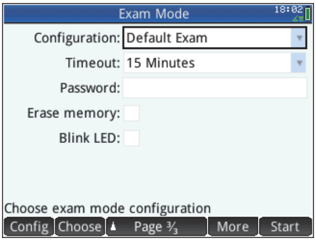
   If you want to activate exam mode now, continue with “Activating Exam Mode” below.

Activating Exam Mode

When you activate exam mode you prevent users of the calculator from accessing those features you have disabled. The features become accessible again at the end of the specified time-out period or on entry of the exam-mode password, whichever occurs sooner.

To activate exam mode:

1. tIf the **Exam Mode** screen is not showing, press Shift Settings, tap Page 1/4 and tap Page 2/4.



2. If a configuration other than `Default Exam` is required, choose it from the **Configuration** list.
3. Select a time-out period from the **Timeout** list.

   Note that 8 hours is the maximum period. If you are preparing to supervise a student examination, make sure that the time-out period chosen is greater than the duration of the examination.
4. Enter a password of between 1 and 10 characters. The password must be entered if you—or another user—wants to cancel exam mode before the time-out period has elapsed.
5. If you want to erase the memory of the calculator, select **Erase memory**. This will erase all user entries and return the calculator to its factory default settings.
6. If you want the exam mode indicator to flash periodically while the calculator is in exam mode, select **Blink LED**.
7. Using the supplied USB cable, connect a student's calculator.

   Insert the micro-A connector—the one with the rectangular end—into the USB port on the sending calculator, and the other connector into the USB port on the receiving calculator.
8. To activate the configuration on an attached calculator, tap Start. The **Exam Mode** screen closes. The connected calculator is now in exam mode, with the specified disabled features not accessible to the user of that calculator.

9. Repeat from step 7 for each calculator that needs to have its functionality limited.

Cancelling exam mode

If you want to cancel exam mode before the set time period has elapsed, you will need to enter the password for the current exam mode activation.

1. Connect the calculator that is in exam mode.
2. If the **Exam Mode** screen is not showing, press Shift Settings, tap Page 1/4 and tap Page 2/4.
3. Enter the password for the current exam mode activation and tap OK twice.

Modifying configurations

Exam mode configurations can be changed. You can also restore the default configuration.

To change a configuration

1. If the **Exam Mode** screen is not showing, press Shift Settings, tap Page 1/4 and tap Page 2/4.
2. Select the configuration you want to change from the Configuration list.
3. Tap Config.
4. Make whatever changes are necessary and then tap OK.

Deleting configurations

You cannot delete the default exam configuration (even if you have modified it). You can only delete those that you have created. To delete a configuration:

1. If the **Exam Mode** screen is not showing, press Shift Settings, tap Page 1/4 and tap Page 2/4.
2. Select the configuration you want to delete from the **Configuration** list.

3. Tap More and choose `Delete`.
4. When asked to confirm the deletion, tap OK or press Enter.

Appendix A

Glossary

app	A small application, designed for the study of one or more related topics or to solve problems of a particular type. The built-in apps are Geometry, Function, Solve, Statistics 1Var, Statistics 2Var, Inference, Parametric, Polar, Sequence, Finance, Linear Solver, Triangle Solver, Linear Explorer, Quadratic Explorer, Trig Explorer, Spreadsheet, Advanced Graphing and Datastreamer. An app 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.
button	An option or menu shown at the bottom of the screen and activated by touch. Compare with *key*.
CAS	Computer Algebra System. Use the CAS to perform calculations in symbolic mode. Such calculations always return exact answers (unlike calculations done in Home view, which yield numeric approximations). You can share results and variables between the CAS and Home view (and vice versa).
catalog	A collection of items, such as matrices, lists, programs and the like. New items you create are saved to a catalog, and you choose a specific item from a catalog to work on it. A special catalog that lists the apps is called the Application Library.

command	An operation for use in programs. Commands can store results in variables, but do not display results.
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.
Home view	The basic starting point of the calculator. Most calculations can be done in Home view. However, such calculations only return numeric approximations. For exact results, you can use the CAS. You can share results and variables between the CAS and Home view (and vice versa).
input form	A screen where you can set values or choose options. Another name for a dialog box.
key	A key on the keypad (as opposed to a button, which appears on the screen and needs to be tapped to be activated).
Library	A collection of items, more speficially, the the apps. See also *catalog*.
list	A set of values separated by commas and enclosed in braces. Lists are commonly used to enter statistical data and to evaluate a function with multiple values. Created and manipulated by the List Editor and.
matrix	A two-dimensional array of values separated by commas and enclosed in nested square brackets. Created and manipulated by the Matrix Editor. Vectors are also handled by the Matrix Editor.

menu	A choice of options given in the display. It can appear as a list or as a set of touch buttons across the bottom of the display.
note	Text that you write in the Note Editor. It can be a general, standalone note or a note specific to an app.
program	A reusable set of instructions that you record using the Program Editor.
variable	A name given to an object—such as a number, list, matrix, graphic and so on—to assist in later retrieving it. The Sto ▸ command assigns a variable, and the object can be retrieved by selecting the associated variable from the variables menu (Vars Chars A).
vector	A one-dimensional array of values separated by commas and enclosed in single square brackets. Created and manipulated by the Matrix Editor.
views	The six primary environments for creating and manipulating apps: Plot, Plot Setup, Numeric, Numeric Setup, Symbolic, and Symbolic Setup.

Appendix B

Troubleshooting

Calculator not responding

If the calculator does not respond, you should first try to reset it. This is much like restarting a PC. It cancels certain operations, restores certain conditions, and clears temporary memory locations. However, it does not clear stored data (variables, apps, programs, etc.).

To reset

Press and hold On/Off and Symb/Setup simultaneously, and then release them.

If this doesn't work, you should restore factory settings (see below).

To restore factory settings

If the calculator does not respond to a reset (see above), you should restore factory settings. This will entirely erase the calculator's memory. *You will lose everything you have stored.*

1. Press and hold On/Off then Apps/Info and then Esc/Clear.
2. Release all keys in the reverse order.

If the calculator does not turn on

If the HP Prime does not turn on, follow the steps below until the calculator turns on. You may find that the calculator turns on before you have completed the procedure. If the calculator still does not turn on, contact Customer Support for further information.

1. Press and hold On/Off for 10 seconds, then release.

2. Press and hold On Off and simultaneously, then release , then release On Off.
3. Press and hold On Off, , and simultaneously. Release , then release , and then release On Off.
4. Remove the batteries, press and hold On Off for 10 seconds, then put the batteries back in and press On Off.

Operating 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 operates at 6.0V dc, 80mA maximum.

Status messages

Message	Meaning
Bad Argument Type	Incorrect input for this operation.
Bad Argument Value	The value is out of range for this operation.
Infinity error	Math exception, such as 1/0.
Insufficient Memory	You must recover some memory to continue operation. Delete one or more customized apps, matrices, lists, notes, or programs.
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.

Message	Meaning (Continued)
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 in the Symbolic view before entering the Plot view.
Receive Error	Problem with data reception from another calculator. Re-send the data.
Too Few Arguments	The command requires more arguments than you supplied.
Undefined Name	The global variable named does not exist.
Undefined Result	The calculation has a mathematically undefined result (such as 0/0).
Out of Memory	You must recover a lot of memory to continue operation. Delete one or more customized apps, matrices, lists, notes, or programs.

Appendix C

Product Regulatory Information

Federal Communications Commission Notice

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and the receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio or television technician for help.

Modifications

The FCC requires the user to be notified that any changes or modifications made to this device that are not expressly approved by Hewlett-Packard Company may void the user's authority to operate the equipment.

Cables

Connections to this device must be made with shielded cables with metallic RFI/EMI connector hoods to maintain compliance with FCC rules and regulations. Applicable only for products with connectivity to PC/laptop.

Declaration of Conformity for products Marked with FCC

Logo, United States Only

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

If you have questions about the product that are not related to this declaration, write to:
Hewlett-Packard Company
P.O. Box 692000, Mail Stop 530113
Houston, TX 77269-2000

For questions regarding this FCC declaration, write to:
Hewlett-Packard Company
P.O. Box 692000, Mail Stop 510101 Houston, TX 77269-2000 or call HP at 281-514-3333

To identify your product, refer to the part, series, or model number located on the product.

Canadian Notice

This Class B digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Avis Canadien

Cet appareil numérique de la classe B respecte toutes les exigences du Règlement sur le matériel brouilleur du Canada.

European Union Regulatory Notice

Products bearing the CE marking comply with the following EU Directives:

- Low Voltage Directive 2006/95/EC
- EMC Directive 2004/108/EC
- Ecodesign Directive 2009/125/EC, where applicable

CE compliance of this product is valid if powered with the correct CE-marked AC adapter provided by HP.

Compliance with these directives implies conformity to applicable harmonized European standards (European Norms) that are listed in the EU Declaration of Conformity issued by HP for this product or product family and available (in English only) either within the product documentation or at the following web site: **www.hp.eu/certificates** (type the product number in the search field).

The compliance is indicated by one of the following conformity markings placed on the product:

For non-telecommunications products and for EU harmonized telecommunications products, such as Bluetooth® within power class below 10mW.

For EU non-harmonized telecommunications products (If applicable, a 4-digit notified body number is inserted between CE and !).

Please refer to the regulatory label provided on the product.
The point of contact for regulatory matters is:
Hewlett-Packard GmbH, Dept./MS: HQ-TRE, Herrenberger Strasse 140, 71034 Boeblingen, GERMANY.

Japanese Notice

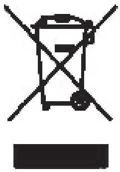
この装置は，クラスB情報技術装置です。この装置は，家庭環境で使用することを目的としていますが，この装置がラジオやテレビジョン受信機に近接して使用されると，受信障害を引き起こすことがあります。

取扱説明書に従って正しい取り扱いをして下さい。 VCCI－B

Korean Class Notice

B급 기기 (가정용 방송통신기기)	이 기기는 가정용(B급)으로 전자파적합등록을 한 기기로서 주로 가정에서 사용하는 것을 목적으로 하며, 모든 지역에서 사용할 수 있습니다.

Disposal of Waste Equipment by Users in Private Household in the European Union



This symbol on the product or on its packaging indicates that this product must not be disposed of with your other household waste. Instead, it is your responsibility to dispose of your waste equipment by handing it over to a designated collection point for the recycling of waste electrical and electronic equipment. The separate collection and recycling of your waste equipment at the time of disposal will help to conserve natural resources and ensure that it is recycled in a manner that protects human health and the environment. For more information about where you can drop off your waste equipment for recycling, please contact your local city office, your household waste disposal service or the shop where you purchased the product.

Chemical Substances

HP is committed to providing our customers with information about the chemical substances in our products as needed to comply with legal requirements such as REACH (*Regulation EC No 1907/2006 of the European Parliament and the Council).* A chemical information report for this product can be found at:

http://www.hp.com/go/reach

Perchlorate Material - special handling may apply
This calculator's Memory Backup battery may contain perchlorate and may require special handling when recycled or disposed in California.

产品中有毒有害物质或元素的名称及含量

根据中国《电子信息产品污染控制管理办法》

部件名称	有毒有害物质或元素					
	铅 (Pb)	汞 (Hg)	镉 (Cd)	六价铬 (Cr(VI))	多溴联苯 (PBB)	多溴二苯醚 (PBDE)
PCA	X	O	O	O	O	O
外觀殼 /字鍵	O	O	O	O	O	O

O：表示该有毒有害物质在该部件所有均质材料中的含量均在SJ/T 11363-2006标准规定的限量要求以下。

X：表示该有毒有害物质至少在该部件的某一均质材料中的含量超出SJ/T 11363-2006标准规定的限量要求。

表中标有"X" 的所有部件都符合欧盟RoHS法规

"欧洲议会和欧盟理事会2003年1月27日关于电子电器设备中限制使用某些有害物质的2002/95/EC号指令"

注：环保使用期限的参考标识取决于产品正常工作的温度和湿度等条件

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