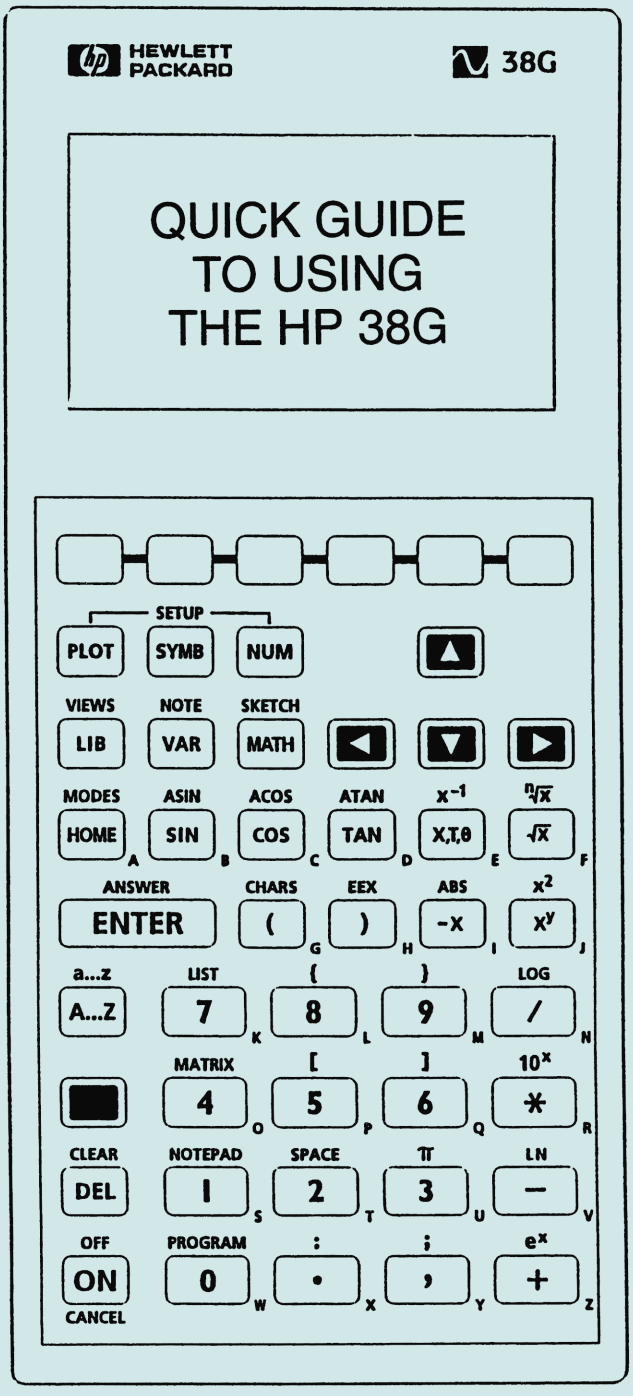
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38G
QUICK GUIDE TO USING THE HP 38G
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PLOT
SYMB
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VIEWS
LIB
NOTE
VAR
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MATH
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HOME
ASIN
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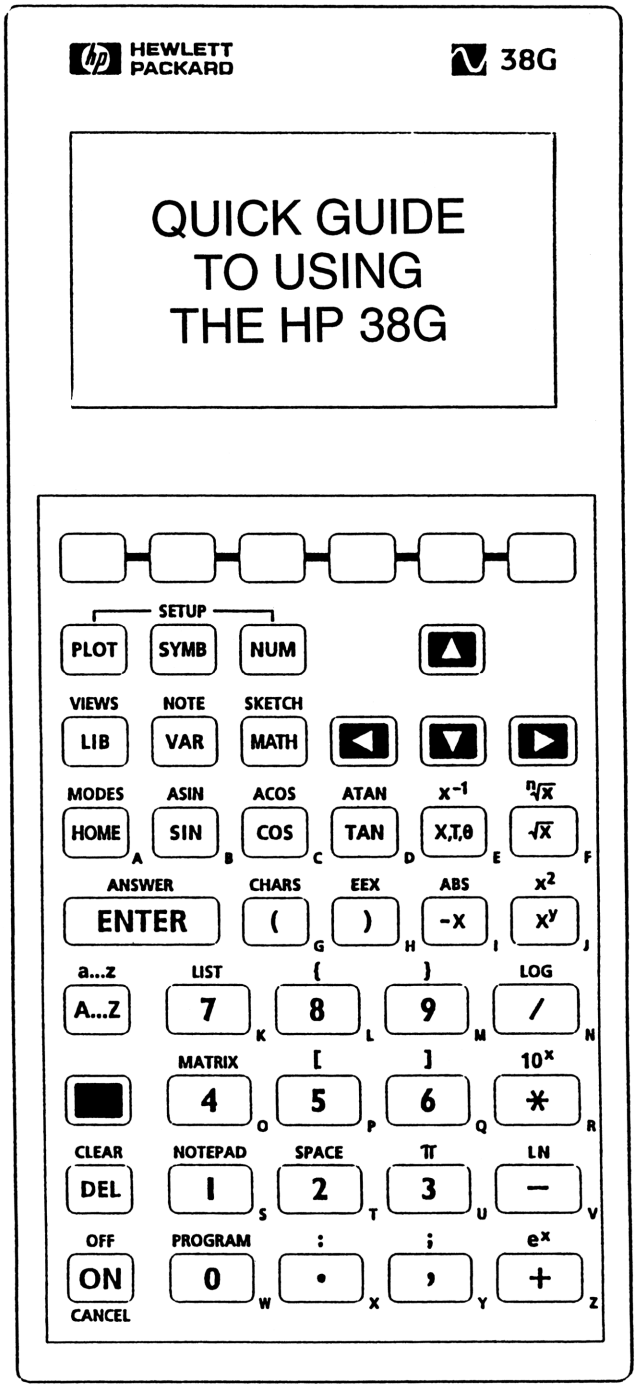
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PROGRAM
ON
CANCEL
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# Table of Contents

# Introduction

The HP 38G is an advanced, algebraic-entry graphing calculator that:

- Offers easy retrieval of previous answers and entries;
- Displays algebraic expressions in "textbook" format;
- Generates tables (including a ZOOM feature);
- Displays two graphs or a graph & table on a vertical split-screen;
- Works with functions, parametric and polar equations;
- Works with sequences (including recursion);
- Solves equations;
- Computes and organizes statistical data;
- Offers symbolic algebra and tools for calculus;
- Operates with vectors, matrices, lists, and complex numbers;
- Draws and annotates diagrams;
- Saves and shares equations and machine settings;
- Offers full programmability.

This guide is intended to give you a quick beginning overview of the basic features of the HP 38G and also to serve as a quick reference guide. We suggest you use it to get started using your HP 38G, and you may find it handy for reference in the future. (Of course, much more detailed information can be found in your owner's manual.)

Unlike a reference manual, the contents of this short guide are ordered in a sequence that we believe you'll find most useful for getting acquainted with the HP 38G. In other words, if you start to work through the guide from the beginning, you will encounter the most basic (and most used) features of the calculator first. Indeed, the first half of the guide should get you comfortable quickly with performing computations, entering formulas, graphing functions, and working with variables. The rest of the guide will then introduce you to how you use your HP 38G with a variety of additional mathematics topics: parametric and polar equations, sequences, equation solving, complex numbers, lists, vectors, matrices, and statistics.

### *Conventions*

In this guide, keys that appear on the HP 38G keyboard are shown in boxes, like this: [MATH] or [ENTER] or [SIN]. The directional arrow keys are denoted by ▲, ▼, ▶, and ◀; and the shift key appears as ■.

The six blank keys just below the HP 38G display are menu selection keys, whose meanings vary, depending upon the six menu items appearing just above them in the display, items such as STO, COPY or ECHO.

☞ *A pointing hand gives extra attention to warnings, suggestions, helpful hints, shortcuts, or other important notes.*

Enjoy the tour!

# 1. Basic Information

The cover of the HP 38G stays attatched to the calculator at all times. It swivels onto the back for use. When you're done, swivel the cover back over the keyboard for protection.

### *The ON Key*

The ON key (lower left corner) not only powers up your HP 38G but also serves as a general purpose CANCEL key (as noted beneath).

If you leave your calculator on for a few minutes without pressing any keys, then it will automatically shut off to save battery power. When you press ON again, the screen should be just as you left it. The memory of the calculator is continuously maintained, even when the calculator is off.

### *Contrast Control*

To lighten or darken the screen to your preference, just hold down ON while pressing − or +, respectively.

### *Batteries*

The HP 38G uses three AAA batteries, located in the lower compartment in the back of the calculator. A set of batteries should last several months. Even when you remove the batteries, the calculator's memory is maintained for a few minutes, to let you change batteries without losing stored information.

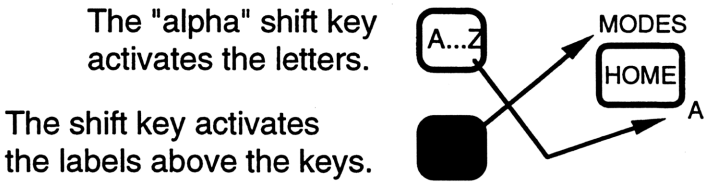
### *Ports*

On the upper part othe HP 38G's back side are its "doors to the outside world." The 10-prong serial port connects to a Macintosh, a PC-compatible computer, or an overhead device. In addition, two infrared "eyes" offer wireless communication with other calculators or printers (the infrared beams go right through the cover). Notice the small arrow on the top front edge, to help you line up the beam of your HP 38G with the other device.

### *Shift Keys*

Right below [ENTER] are two shift keys. These keys act as "toggles"—if you accidentally press one, just press it again to turn it off.

You press the colored shift key (denoted here as ■) to activate any operation or menu indicated by a colored label directly above a key. Notice that when the ■ key has been pressed, a shift symbol, ⇦, is displayed at the top of the screen.




The [A...Z] key accesses the letters of the alphabet appearing to the lower right of most keys on the bottom six rows. When this shift key has been pressed, an α appears at the top of the screen ("alpha" for alphabet).

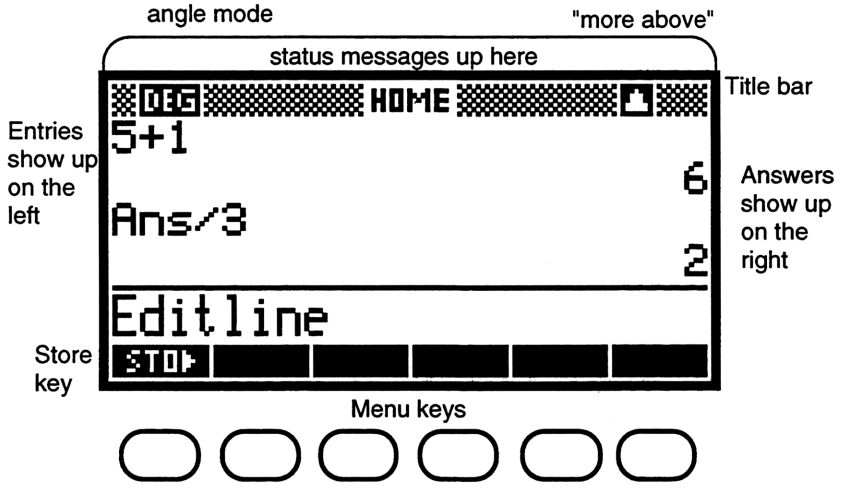
☞ *Helpful Hint: When typing several letters in a row, simply hold [A...Z] down as you type.*

Lower case letters are obtained by pressing ■ [A...Z] or [A...Z] ■. Greek letters and other special symbols may be found in the [CHARS] menu.

# 2. The HOME Screen

The HOME screen is the primary work area for the HP 38G. Think of it as your "home" base of operations. To go to the HOME screen, press HOME.

### *A Tour of the HOME Screen*




Messages about the calculator's status and modes are displayed at the top of your screen. For example, if you see DEG at the top of the screen, the calculator will use degrees in any computations involving angle measure.

Whenever a little ⧖ appears at the top of the screen (above the title bar), the HP 38G is "busy" with a calculation. Pressing ON while this *annunciator* is on will stop the computation. Another annunciator, (•), will tell you when your batteries are getting low—you should change them within a few days. (The HP 38G will also give a Low Battery message when you turn it on.)

Whenever you find yourself in an unfamiliar situation or are unsure how to "quit" or "exit," try pressing HOME to bring you back to the HOME screen, the main calculation area for the HP 38G.

### *Entering*

When you type, the characters appear on the Editline until you press [ENTER]:

| Example | Keystrokes | Display |
|---|---|---|
| To enter 2: | [2] [ENTER] | 2<br>2 |
| To enter $2.5x10^{38}$: | [2] [•] [5] [EEX] [3] [8] [ENTER] | 2.5E38<br>2.5E38 |

### *Deleting and Clearing*

When you type, you'll see a flashing cursor arrow. If you make a mistake, then pressing [DEL] will erase the last character you typed. If you use the directional arrows, ▶ and ◀, to position the cursor on top of a character, then pressing [DEL] will erase that character.

To delete the entire Editline, press [CANCEL] ([ON]).

To clear all previous entries and answers off the HOME screen, use [CLEAR] ([■] [DEL]).

> ☞ *The flashing cursor arrow is always in "insert" mode on the HOME screen. In other words, it always points to where the next character you type will be inserted.*

### *Retrieving and Editing*

The [ANSWER] key ([■][ENTER]) echoes a special variable, Ans, to the Editline. The value of this variable is the last answer you obtained for an operation on the HOME screen. This allows you to immediately use a result in a new computation without having to type it in from scratch.

In fact, until you press [CLEAR], a history of *all* your previous entries and answers is maintained on the HOME screen. At any time you can copy a previous entry or answer down to the Editline. Simply use the ▲ key until you have highlighted the entry or answer you want, then press the COPY key to copy the highlighted entry or answer into the Editline. Then, to make changes, use the ◀ and ▶ keys to move the cursor where you want it. Any characters you type will be inserted where the cursor is pointing. Pressing [DEL] will delete the character underneath the flashing cursor. After you make the desired changes, press [ENTER].

Example: Press [CLEAR] ([■][DEL]), then: Display

[3][*][2][ENTER][4][/][8][ENTER][5][+][1][ENTER]

```
                4/8
                        .5
                5+1
                          6
```

To negate the last answer: [-][X][ANSWER]

```
               -Ans
                         -6
```

Your first two entries are out of view but still on the HOME screen. The ▲ in the screen's upper right shows that there are more entries and answers above the visible part of the screen. So press ▲ to activate the highlight bar. Now you can move up and down the screen via ▲ and ▼. (the ▲ and ▼ show you how you can move, and ! tells you when you hit top or bottom).

To add your first two entries, highlight 3*2, COPY, and press [+]. Now highlight 4/8, COPY, and press [ENTER]:

```
             3*2+4/8
                        6.5
```

### *Showing an Expression*

When you use ▲ and ▼ to highlight a previous entry or answer, you'll see another menu key labeled SHOW.

SHOW typesets the entry or answer in "textbook" format. You can use it to check to see if you have really entered an expression with the meaning that you intended—particularly helpful for checking the format of a complicated expression by visually matching it to the notation in a book or your notes.

Example: Evaluate the expression $\frac{1}{\sqrt{3^2+4^2}} - 5$

1 / √x ( 3 x^y 2 + 4 x^y 2 ) − 5 ENTER

```
1/√(3^2+4^2)-5
                -4.8
```

Press ▲ twice to highlight the expression and press SHOW to "typeset" it (this will take several moments). When you finish looking at the typeset version, simply press OK.

### *Storing Numbers in Variables*

The letters A-Z and θ are reserved as variable names for real numbers. To store a number (or other object) under a variable name, type in the number or expression on the Editline of the HOME screen, press STO▶, type the name of the variable, and press ENTER.

| Examples | Keystrokes | Display |
|---|---|---|
| Store 3 in the variable W: | 3 STO▶ W ENTER | 3▶W<br>3 |
| Recall the value in W: | W ENTER | W<br>3 |
| Use W in an expression: | W x^y 4 ENTER | W^4<br>81 |

# 3. MODES

Press the MODES key (▀ HOME) to see the settings that control the HOME screen display. You move about the screen with the arrow keys. When any item is highlighted, pressing the CHOOS menu selection will show you the choices available to "fill in" that blank.

### *Angle Measure*

There are three angle measure modes:

| | |
|---|---|
| Degrees | (360° per circle) |
| Radians | ($2\pi$ radians per circle) |
| Grads | (400 grads per circle) |

To make a selection, press the CHOOS key with the current angle measure highlighted. A box appears with the three choices. Use ▲ and ▼ to highlight the one you want, and press ▒OK▒ or ENTER to select it. (If you change your mind, press CANCEL to maintain the original setting.)

### *Number Format*

The standard numeric display mode of the HP 38G is for 12 significant digits (15 digits are carried internally during computation). Your HP 38G is in standard display mode if the number format reads Standard. There are five number formats to CHOOS from:

| | |
|---|---|
| Standard | Up to 12 digits shown with a floating decimal point. |
| Fixed | Fixed number of decimal places chosen, from 0-11. |
| Scientific | Exponential notation (one digit left of the decimal point; no. of places after first significant digit chosen, 0-11). |
| Engineering | Exponential notation (exponent is a multiple of 3; number of places after first significant digit is chosen, 0-11). |
| Fraction | Numbers displayed as fractions in "P/Q" format; max. no. of digits in numerator or denominator chosen, 0-11. |

### *Examples*

In Standard number format, go [HOME] and enter [1][2][3][4][5][.][6][7][8][9]

```
                                  12345.6789
                                  12345.6789
```

Go to [MODES], [CHOOSE] Fixed number format and 2 decimal places.
[HOME][ANSWER][ENTER]

```
                                  Ans
                                  12345.68
```

Go to [MODES], [CHOOSE] Scientific number format (still 2 decimal places).
[HOME][ANSWER][ENTER]

```
                                  Ans
                                  1.23E4
```

Go to [MODES], [CHOOSE] Engineering number format (still 2 decimal places).
[HOME][ANSWER][ENTER]

```
                                  Ans
                                  12.3E3
```

Go to [MODES], [CHOOSE] Fraction number format (with 2 digits maximum).
[HOME][π][ENTER]

```
                                  π
                                  22/7
```

Go to [MODES], [CHOOSE] Fraction number format (with 3 digits maximum).
[HOME][π][ENTER]

```
                                  π
                                  333/106
```

☞ *You will likely find that* Standard *format serves most general purposes best.*

### *Decimal Mark and Title*

You can also change the decimal mark to the European comma (, ). You can even change the title displayed at the top of HOME screen if you want. But you probably won't want to change either of these.

### *Resetting the MODES*

In MODES, pressing [CLEAR] ([■][DEL]) resets all the modes to default settings.

# 4. Computational Examples

The HP 38G uses algebraic-entry notation—*not* RPN (Reverse Polish Notation). Some examples follow. All answers are in Standard format.

### *Arithmetic Operations*

Addition: [2][6][+][8][2][ENTER]

```
26+82
                    108
```

Subtraction: [8][6][−][3][2][ENTER]

```
86-32
                     54
```

Negation: [-X][2][ENTER]

```
-2
                     -2
```

Multiplication: [6][2][*][4][5][ENTER]

```
62*45
                   2790
```

Division: [8][5][/][2][0][ENTER]

```
85/20
                   4.25
```

Exponentiation: [4][2][$x^y$][5][ENTER]

```
42^5
                130691232
```

Square roots: [$\sqrt{x}$][2][0][ENTER]

```
√20
             4.472135955
```

Squares: [2][5][$X^2$][ENTER]
(Note how [$X^2$] produces a superscript)

```
25²
                    625
```

Reciprocals: [8][5][$x^{-1}$][ENTER]
(that's .0117647058824)

```
85^-1
    1.17647058824E-2
```

Powers of 10: [10^x] [3] [ENTER]

```
10^3
                1000
```

Absolute value: [■] [ABS] [−] [5] [)] [ENTER]

```
ABS(-5)
                   5
```

Complex numbers: [√x] [(] [−] [4] [)] [ENTER]

```
√(-4)
              (0,2)
```

*nth* roots: [5] [ⁿ√x] [(] [−] [3] [2] [)] [ENTER]

```
5 NthRoot (-32)
                  -2
```

CAPS on 38

Notice that function keys often supply the left parenthesis for you. In fact, it is not necessary for you even to supply the right parenthesis to finish an entry (unless you need to clarify the intended meaning)—just [ENTER].

### *Transcendental Functions*

With the angle measure in [MODES] set to Degrees:

Trig functions: [COS] [6] [0] [ENTER]

```
COS(60
                  .5
```

Inverse trig functions: [ACOS] [0] [ENTER]

```
ACOS(0
                 90
```

With the angle measure in [MODES] set to Radians:

Trig functions: [SIN] [π] [/] [2] [ENTER]

```
SIN(π/2
                   1
```

Inverse trig functions: [ATAN] [1] [ENTER]

```
ATAN(1
          .785398163397
```

Natural exponentials: [$e^x$] [1] [0] [ENTER]

```
e^10
                22026.4657948
```

Common (base 10) logarithms: [■] [LOG] [2] [ENTER]

```
LOG(2
              .301029995664
```

Natural (base *e*) logarithms: [■] [LN] [3] [ENTER]

```
LN(3
              1.09861228867
```

### *Special Numbers*

The real number $\pi$: [■] [π] [ENTER]

```
π
              3.14159265359
```

The real number *e*: [A...Z] [■] [E] [ENTER]

```
e
              2.71828182846
```

The complex number, *i*: [A...Z] [■] [I] [ENTER]

```
i
                      (0,1)
```

### *Pop Quiz*

A famous result: What is $e^{\pi i}+1$?

Which is greater, $e^{\pi}$ or $\pi^{e}$?

What is $\ln(-1)$?

### *Implied Multiplication*

In most cases on the HP 38G, juxtaposition of two number quantities implies multiplication. Here are some examples to illustrate:

4 ( 1 + 2 ) $x^y$ 3 ENTER

```
4*(1+2)^3
                                  108
```

☞ *Note how the multiplication symbol is entered for you.*

3 STO▶ A ENTER

```
3▶A
                                    3
```

4 STO▶ B ENTER

```
4▶B
                                    4
```

2 A...Z A ENTER

```
2*A
                                    6
```

A...Z A A...Z B ENTER

```
A*B
                                   12
```

5 A...Z A $x^y$ 4 ENTER

```
5*A^4
                                  405
```

With the angle measure in MODES set to Degrees:

A...Z A COS 0 ) ENTER gives

```
A*COS(0)
                                    3
```

Note the space that appeared on the Editline when you pressed COS immediately after typing A. This space appeared because there was a chance of ambiguity in the function name. The explicit multiplication symbol, *, makes clear the meaning of the expression. If you had deleted the space between A and COS(0) before pressing ENTER, you would have instead obtained

```
ACOS(0)
                                   90
```

which is the inverse cosine of 0.

# 5. LIB and ApLets

The primary tools for working with functions, equations, and data are activated in the LIB (LIBrary) menu. Press LIB to see a menu like the following:


### *What is an ApLet?*

Built into the HP 38G are six main "super" settings, called *ApLets*:

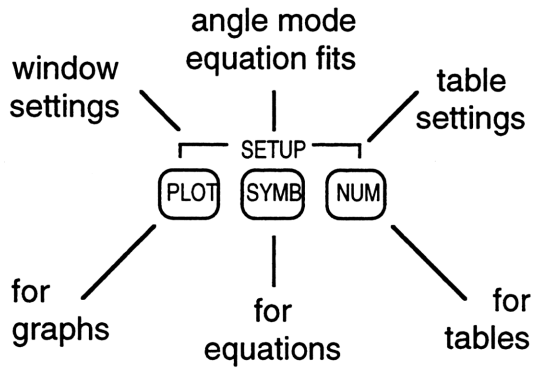
| | |
|---|---|
| Function | for working with functions of the form $y = f(x)$. |
| Parametric | for working with parametric equations $x(t)$, $y(t)$. |
| Polar | for working with polar functions $r(\theta)$. |
| Sequence | for working with sequences $\{u_n\}$ $(n = 1, 2, ...)$. |
| Solve | for working with equations of one or more variables. |
| Statistics | for working with numerical data. |

For working in each of these ApLets, the HP 38G has:

| | |
|---|---|
| *graphical tools* (in PLOT) | to plot and analyze graphs of functions, equations, and data; |
| *symbolic tools* (in SYMB) | to enter and view formulas and fit equations to data; |
| *numerical tools* (in NUM) | to make tables of function values or data, or to analyze equations. |

### *Starting an ApLet*

To activate an ApLet—say, Function—you highlight it in the LIB screen and press START (or ENTER) from the LIB menu. This takes you automatically to the FUNCTION SYMBOLIC VIEW (i.e. just as if you had pressed SYMB), where you can enter or edit your function formulas.* You can then move to FUNCTION PLOT VIEW (via PLOT), or to FUNCTION NUMERIC VIEW (via NUM) to see a graph or table of values for the selected functions.




☞ *One of the ApLets is always "active"—i.e. showing these three views (PLOT, SYMBOLIC, NUMERIC). The default ApLet is* Function.

If you are familiar with the TI-82 calculator, here is a rough correspondence:

| HP 38G | TI-82 | HP 38G | TI-82 |
|---|---|---|---|
| PLOT | GRAPH | ■ PLOT (SETUP) | WINDOW |
| SYMB | Y= | ■ SYMB (SETUP) | MODE |
| NUM | TABLE | ■ NUM (SETUP) | TblSet |

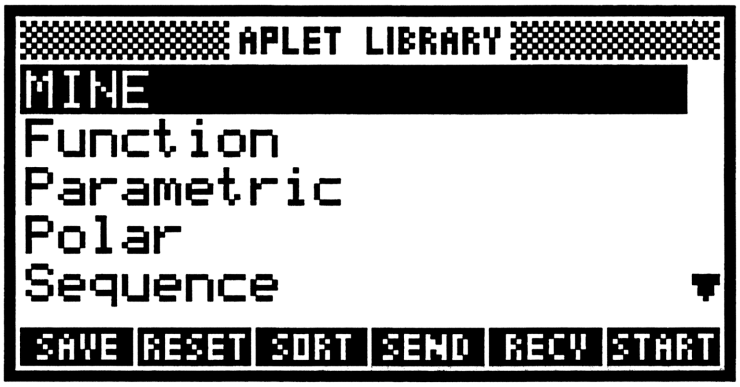
Note that on the HP 38G, you set all modes related to graphing under the PLOT SETUP (■ PLOT), while on the TI-82, these modes are found with the other modes.

*Pressing START always takes you to the SYMBOLIC VIEW (i.e. SYMB) for any of the ApLets you highlight in the LIBrary, except Statistics, for which START takes you to the STATISTICS NUMERIC VIEW (i.e. NUM), so that you can enter or edit your statistical data.

### *Saving an ApLet*

The SAVE selection on the LIB menu lets you save a set of functions, equations, or data, along with particular settings for graphs and tables. You can even save textual notes (via NOTE) or sketch a diagram or picture (via SKETCH) to go with your saved version of the ApLet. When you press SAVE you are prompted for a name. After you type in the name of your choice, you press OK or ENTER (or CANCL or ON to cancel). Note that the A...Z key on the menu is an "alpha lock" that can be toggled on or off.

For example, if you type in MINE as the name of your ApLet and press OK, you will see MINE listed in the APLET LIBRARY, along with the usual six built-in ApLets:




At any time in the future, you can recover all these formulas, data, and settings: Just press LIB, highlight MINE, and press START. If you change some of these formulas or settings, you have the options either to RESET MINE to its original version or to SAVE it again with the changes you have made.

### *Deleting and Clearing ApLets*

To delete a saved ApLet, highlight its name in the APLET LIBRARY and press [DEL]. (Of course, the HP 38G will not allow you to delete one of the six built-in ApLets.) If you want to delete *all* the saved ApLets, press [CLEAR].

### *Sorting, Sending, and Receiving ApLets*

SORT offers a choice of two orderings of the APLET LIBRARY menu:

> Chronological displays all ApLets in order of most recent use.
> Alphabetical displays all ApLets in alphabetical order.

SEND lets you send a highlighted ApLet to another HP 38G or to a disk drive.

RECV lets you receive a highlighted ApLet from another HP 38G or from a disk drive.

# 6. Functions

Press [LIB], highlight Function, and press [ENTER]. This automatically "presses" [SYMB], and you'll see FUNCTION SYMBOLIC VIEW, with a list of your functions:

```
F1(X)=
F2(X)=
F3(X)=
F4(X)=
F5(X)=
```

There are 10 dedicated function variables F1, F2, ..., F9, F0. You can use ▲ and ▼ to scroll through the entire list.

### *The Independent Variable Key,* [X,T,θ]

When the Function ApLet is activated, [X,T,θ] provides the variable X whenever you press it. For example, to enter the sine function, highlight F1(X)= and type [SIN][X,T,θ] [ENTER]. Result: √F1(X)=SIN(X)

Note how the closing parenthesis is provided for you. The √ indicates that F1(X) is now selected for graphing or making a table. Whenever you enter a function, it is automatically selected, and the next function is highlighted.

With F2(X)= highlighted, type [COS][X,T,θ] [ENTER].
With F3(X)= highlighted, type [A...Z][F][1][X,T,θ][)][/][A...Z][F][2][X,T,θ][)] [ENTER].

You should now see

```
√F1(X)=SIN(X)
√F2(X)=COS(X)
√F3(X)=F1(X)/F2(X)
```

### *The SYMB Menu*

Press SYMB to see these menu items: EDIT ☑CHK X SHOW EVAL

EDIT sends the highlighted function to the Editline where you can edit it. Use OK or ENTER to complete the edit; use CANCL or ON to cancel it.

☑CHK is a "toggle" that selects or unselects the highlighted function. Any number of functions can be selected at any time.

X is simply another X key for typing convenience.

SHOW displays the highlighted function in "textbook" format.

EVAL will evaluate any other functions or variables (except the independent variable) in the highlighted function.

### *Example*

Use ☑CHK to unselect F2(X) and F3(X). Then highlight F3(X)=F1(X)/F2(X) and press EVAL.

√F1(X)=SIN(X)
F2(X)=COS(X)
F3(X)=SIN(X)/COS(X)

Now press SHOW to see $F3(X)=\frac{SIN(X)}{COS(X)}$. Press OK when finished.

### *Deleting and Clearing Functions*

DEL erases the *highlighted* function; CLEAR erases *all* the functions.

☞ *If you use* CLEAR*, the HP 38G will ask if you really want to* Clear All *and offer* NO *and* YES *keys.*

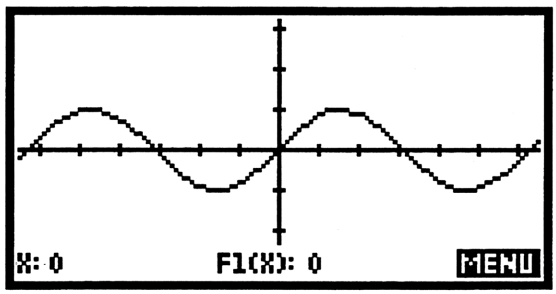
### *Plotting Graphs and Making Tables for Functions*

Press ■ SYMB to get the FUNCTION SYMBOLIC SETUP screen. This is where you can set the angle measure mode for your functions.

*WARNING! This angle measure mode is distinct from the one used by your HOME screen for computations.*

If it is not already indicated, RAD RECT radian mode for the purposes of these graphing examples. Press SYMB to return to the list of function formulas.

■ PLOT brings you to the FUNCTION PLOT SETUP screen. To *reset* all the plot settings (the center of the screen is at the origin, coordinate axes are shown, each axis tick represents one unit, and each pixel is valued at 0.1 unit), press CLEAR. Then press PLOT to see the graph of F1(X)=SIN(X) in the default viewing window (which is [-6.5,6.5]x [-3.1,3.2]):

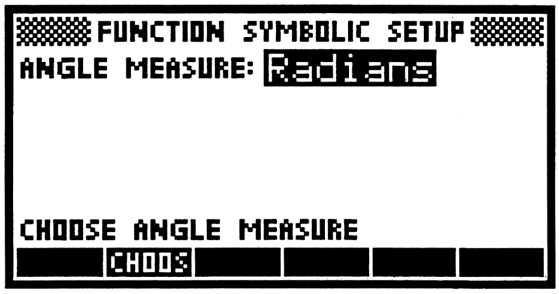


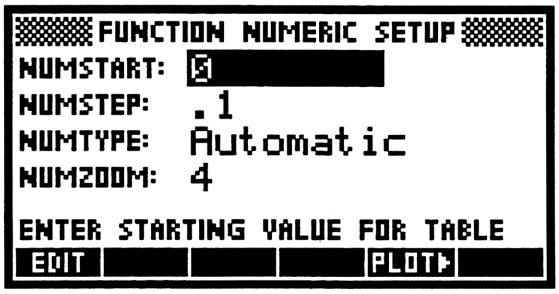

■ NUM brings you to the FUNCTION NUMERIC SETUP screen. To reset all the numeric table settings (the starting value is 0 and incremented in steps of 0.1), press CLEAR. Then press NUM to display a table of values for X and F1(X)=SIN(X):

| X | F1 |
|---|---|
| 0 | 0 |
| .1 | .0998334 |
| .2 | .1986693 |
| .3 | .2955202 |
| .4 | .3894183 |
| .5 | .4794255 |

### *Guide to FUNCTION SETUP Screens*

If you press ■ SYMB you will see the FUNCTION SYMBOLIC SETUP screen, where you set the angle measure mode for working with functions.




And ■ NUM displays the FUNCTION NUMERIC SETUP, where you set these parameters for building a table of values with a function.

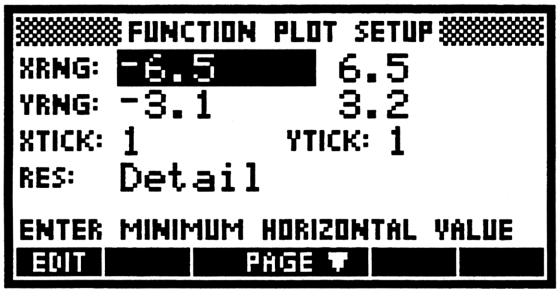
NUMSTART: the starting value for X

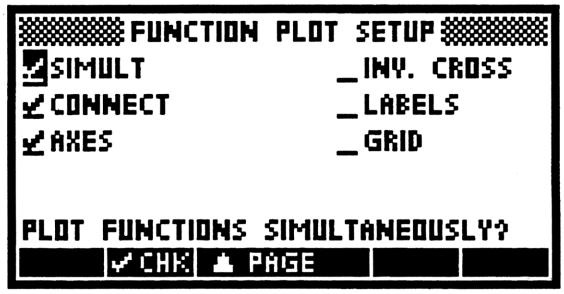
NUMSTEP: the increment for X

NUMTYPE: Automatic lets the HP 38G generate values for X
Build Your Own lets you fill in the values for X

NUMZOOM: The zoom factor for your table

■ PLOT brings you to FUNCTION PLOT SETUP, where you can set the dimensions of the *viewing window* for graphing and set the modes that control how graphs are displayed. There are two pages of settings here; you move between the two screens with PAGE ▼ and ▲ PAGE.




On the first page of the FUNCTION PLOT SETUP are your window settings:

XRNG: XMIN and XMAX (left and right edges of the viewing window)
YRNG: YMIN and YMAX (lower and upper edges of the viewing window)
XTICK: the spacing of the marks on the $x$-axis
YTICK: the spacing of the marks on the $y$-axis
RES: plot resolution (Faster for every other pixels; Detail for every pixel)

☞ *We strongly suggest that you use* Detail *resolution for most of your graphing work. The gain in accuracy far outweighs any speed benefit gained by using* Faster.

To change a highlighted setting, you can either type in the value you want or press EDIT and edit the current setting. When a choice of options is available, a CHOOS key comes up, and pressing it gives you a menu box of available choices. Use the directional arrows ▲ and ▼ to select the desired option. In all cases, you press OK or ENTER to confirm the change and CANCL or ON if you change your mind.

Note that if you press DEL the setting is automatically changed to a default value. The default values for all settings (except RES) are shown in the screens illustrated above.

The second page of the FUNCTION PLOT SETUP has "check blanks" for your graphing modes:

| | |
|---|---|
| SIMULT | check for simultaneous graphing or don't for sequential |
| CONNECT | check for connected graphing or don't for "dot" mode |
| AXES | check to show the $x$-axis and $y$-axis |
| INV. CROSS | check for inverted "crosshairs" (show white on dark) |
| LABELS | check to have axes labeled with their ranges |
| GRID | check to have lattice points plotted (points that line up with the tick marks on both axes) |

As usual, the CHK key allows you to toggle on or off any of these plot mode settings. (Again, the default settings are shown in the illustration opposite.)

# 7. Working with Graphs

These examples will illustrate some of the tools available in PLOT. All the examples are for the Function ApLet, but many of the features are similar for Parametric, Polar, Sequence, Solve, and Statistics.

In LIB, highlight Function, press START. Enter and select F1(X)=SIN(X).

### *The PLOT Menu*

To set up the default viewing window, press ■ PLOT CLEAR. Highlight RES: and CHOOS: Detail. Then press PLOT to see the graph of F1(X)=SIN(X). The directional arrows ◀ and ▶ now move a small crosshairs to *trace* the graph of the function. The coordinates of the crosshairs appear at the bottom of the screen. If you trace all the way to the side of the screen, the graph will *scroll* so that you can continue tracing. If your graph leaves the top or bottom of the screen, the crosshairs will move along the edge of the screen, but the coordinates of points on the graph will still be read out.

Press MENU and the coordinates will disappear to show the PLOT menu:

ZOOM TRACE (X,Y) FCN DEFN MENU

DEFN shows the formula for the current function: F1(X): SIN(X)
(Press MENU to obtain menu labels again.)

The TRACE key toggles the trace feature on and off (the feature is on when you see TRACE; off when you see TRACE). When TRACE is off, the crosshairs move freely off the function graph. (X,Y) displays their coordinates. (MENU reactivates menu labels; TRACE reactivates the TRACE.)

> ☞ *Press MENU MENU to remove both the coordinates and the menu labels. Pressing any of the menu keys now will restore the menu labels.*

## ZOOM Methods

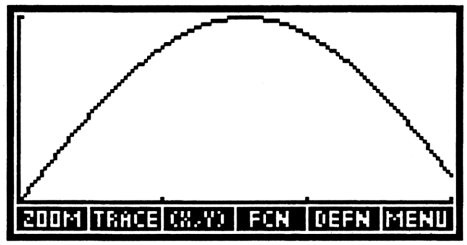
The ZOOM key brings up a menu box with the several zoom methods.

Center centers the screen at the location of the crosshairs (the relative dimensions of the screen remain unchanged).

Box... lets you draw a box to define your new viewing window.

## Example

Select Box... and press OK. You are prompted to select the first corner of the new viewing window. Press OK to make this corner the origin. Now move the crosshairs over to the point (3,1) (a box is stretched). Press OK again—you've changed the viewing window to [0,3]x[0,1].




Other zoom options:

In *zooms in* by the zoom factors shown.

Out *zooms out* by the zoom factors shown.

X-Zoom In *horizontally zooms in* by the zoom factor shown.

X-Zoom Out *horizontally zooms out* by the zoom factor shown.

Y-Zoom In *vertically zooms in* by the zoom factor shown.

Y-Zoom Out *vertically zooms out* by the zoom factor shown.

Square *squares up* the viewing window (so that 1 pixel represents equal horizontal and vertical distances) by resetting YRNG.

Set Factors... allows you to set horizontal and vertical zoom factors (the default is 4 for both factors), and you can also CATLG an option to recenter the screen on the crosshairs.

Un-zoom is an "un-do" key for zooming. It resets the viewing window to its previous settings.

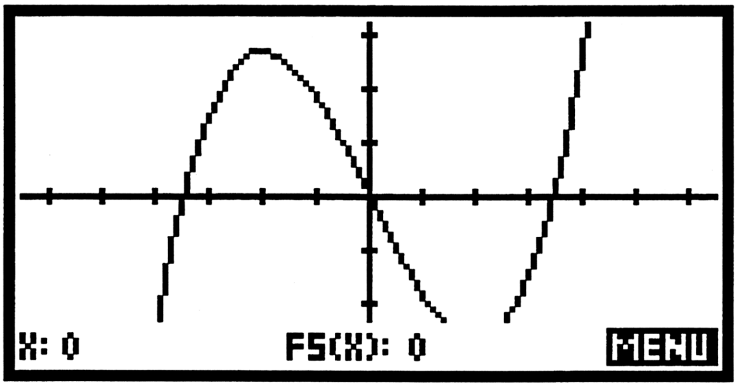
### *The FCN Tools*

The menu key **FCN** in PLOT offers a box of several interactive tools for working with functions.

5

### *Example*

First, press SYMB and enter `F5(X)=X^3/6-2*X`, then use **CHK**, if necessary, to make sure it is the only selected function. Now press ■ PLOT CLEAR for default settings, then set `RES:` to `Detail` and PLOT.




Now try each of the options in the PLOT FCN menu, using this example. To prepare, trace the graph until the crosshairs reaches `X: 3`. Press **MENU** **FCN** to see the menu box with these options:

Note: Replot to clear shading.

Root 3.46410161514
Slope 4.125
Area... Under X Axis 5.957864625 over -5.94864625
Extremum

### *Finding Roots*

Select `Root` and press **OK**. The crosshairs move to the nearest root, display its value, and record it in a variable named `Root`. You should see `ROOT: 3.46410161514` at the bottom of the screen. (Press **MENU** to get the menu labels back on screen.)

### *Finding Slopes*

Move the crosshairs back to the origin. Press **FCN**, select Slope and press **OK**. This finds the derivative of the function at the $x$-coordinate of the crosshairs location, displays it, and records it in the variable Slope. You should see SLOPE: -2 at the bottom of the screen. (Press **MENU** to obtain menu labels again.)

### *Finding Areas*

Press **FCN** and select Area... When you press **OK**, the HP 38G will prompt you for a *starting point* (i.e. the lower limit of integration). Press **OK** now and the starting point is X: 0. Now you're prompted for an *end point* (i.e. the upper limit of integration). Trace over to X: 3.5 near the positive root and watch as the region between the graph and the $x$-axis is shaded.

Press **OK** once again to (numerically) compute the definite integral of the function from the starting point to the end point and record this value in a variable called Area. You should see AREA: -5.99739583334 at the bottom of the screen. (Press **MENU** to obtain menu labels again.)

> ☞ *The* Area... *option computes a definite integral from the left point to the right point, regardless of which ones you selected as the start and end points.*

To clear off the shaded region left by the Area... option, just press PLOT to redraw the function graph.

### *Finding Extrema*

Trace the function until the the crosshairs is near X: -2.5. Select Extremum and press OK to move the crosshairs to the nearest extremum, display its coordinates, and record it in the variable Extremum. (The HP 38G is using a built-in root finder on the derivative of your function.) You should see EXTRM: {-2.2.6666666667} at the bottom of the screen. (Press MENU to obtain menu labels again.)

### *Plotting "Split-Defined" Functions*

A "split-defined" function is one whose formula depends upon the value of the input. For example:

$$f(x) = \begin{cases} x^2 & \text{if } x \le 1 \\ 1 - x & \text{if } x > 1 \end{cases}$$

You can plot a function like this with the HP 38G's function plotter in a couple of different ways:

You could use the expression F6(X)=(X^2)*(X≤1)+(1-X)*(X>1) which has a value $x^2 \bullet 1 + (1-x) \bullet 0$, or $x^2$, when $x \le 1$; and a value $(x^2) \bullet 0 + (1-x) \bullet 1$, or $1-x$, when $x > 1$. This is exactly what you want. Try plotting this using the default viewing window.* (If the HP 38G is in connected mode, then the graph will connect across the jump discontinuity.)

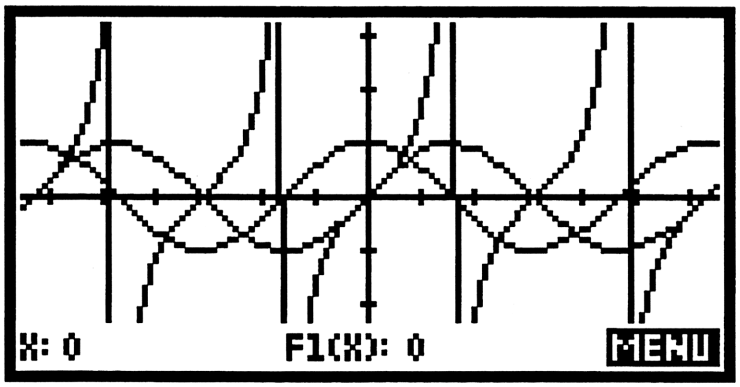
Or, you could use the expression F7(X)=IFTE(X≤1, X^2, 1-X). You can think of this as saying "if $x \le 1$, then evaluate $x^2$, else evaluate $1-x$."

*Note: To obtain symbols like >, press CHARS, highlight the symbol you want, and press OK.

### *Plotting Multiple Functions*

Press SYMB and enter the following functions: √F1(X)=SIN(X)
√F2(X)=COS(X)
√F3(X)=SIN(X)/COS(X)

To plot the three functions together in the default viewing window, press ■PLOT CLEAR, then PLOT. (The plots are either simultaneous or sequential depending on if SIMULT is checked in the FUNCTION PLOT SETUP.)




Use ▲ and ▼ to switch the TRACE crosshairs from graph to graph. You can use DEFN to see the formula for the function currently being traced.

### *Finding Intersections and Areas Between Two Graphs*

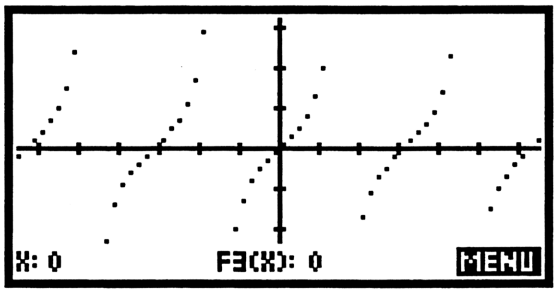
If you have plotted two or more functions, then there is an additional option, Intersection, in the PLOT FCN menu. This option will use the function currently being traced and prompt you to choose one additional function (or the X-Axis). Pressing OK will move the crosshairs to the nearest intersection point of the two selected graphs, display its coordinates, and record the coordinates in the variable Isect.

When you plot multiple functions, the Area... option also lets you select another function, and you can then shade the region between two graphs.

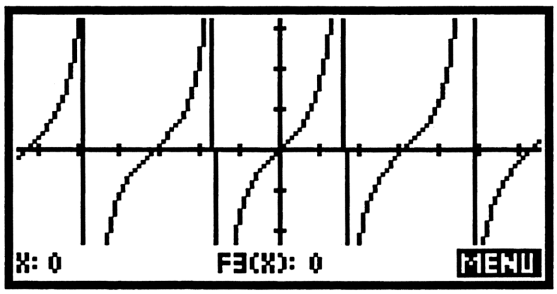
### *Connected vs. Dot Modes For Graphing*

Press ■ PLOT PAGE↓ to go to the second page of the FUNCTION PLOT SETUP. When CONNECTED is unchecked, at most one pixel per column will be lit on a function plot. When CONNECTED is checked, additional pixels are lit to give the graph a continuous appearance. Try an example.

First, make sure that CONNECTED is unchecked. Press SYMB and select √F3(X)=SIN(X)/COS(X) and *unselect* F1(X)=SIN(X) and F2(X)=COS(X). Press PLOT to see the graph in "dot" mode:




To "fill in" the gaps, press ■ PLOT to return to the FUNCTION PLOT SETUP and CHK CONNECTED mode on the second page. Graph the function again by pressing PLOT.




Notice how it *appears* that "vertical asymptotes" have been drawn in. This is not really the case—the HP 38G has simply connected the graph across the asymptotes in this case.

☞ *Note, however, that if an asymptote or other discontinuity in the function falls exactly on the coordinate of a column of pixels, the graph will not connect over the discontinuity, even when the HP 38G is in connected mode.*

# 8. Working with Tables

These examples will illustrate some of the tools available when you press NUM. All the examples are for Function, but many of the features are similar for Parametric, Polar, Sequence, Solve, and Statistics.

Press LIB, highlight Function and START. Enter and select four functions:

√F1(X)=SIN(X)
√F2(X)=COS(X)
√F3(X)=SIN(X)/COS(X)
√F4(X)=COS(X)/SIN(X)

Press ■NUM to go to the FUNCTION NUMERIC SETUP screen. To reset all the numeric table settings, so that the starting value is 0 and values are automatically incremented in steps of 0.1, press CLEAR. Now pressing NUM will display a table of values for X and all four functions.

| X | F1 | F2 | F3 | F4 |
|---|---|---|---|---|
| 0 | 0 | 1 | 0 | UNDEF. |
| .1 | .0998334 | .9950042 | .1003347 | 9.966644 |
| .2 | .1986693 | .9800666 | .20271 | 4.933154 |
| .3 | .2955202 | .9553365 | .3093362 | 3.232728 |
| .4 | .3894183 | .921061 | .4227932 | 2.365222 |
| .5 | .4794255 | .8775826 | .5463025 | 1.830487 |

The directional arrow keys, ▲, ▼, ▶, and ◀, let you move from entry to entry of the table. Not all of the columns fit, but the screen automatically scrolls when you use ▶ to move to the F4 column. New table values are generated as you scroll either up or down with ▲ and ▼.

Notice that when you are on a particular table entry, the full precision of that entry is displayed at the bottom of the screen.

### *The NUM Menu and ZOOM Methods for Tables*

**BIG** is a toggle that allows you to switch back and forth between a large font size and a smaller font size.

**DEFN** shows you `Independent Variable X` when you are in the `x` column; it shows you the formula for the function when you are in one of the columns `F1`, `F2`, `F3`, or `F4`.

**ZOOM** key brings up a menu box with the several zoom methods. `In` will *zoom in* by the designated zoom factor. `Out` will *zoom out* by the designated zoom factor. You specify the zoom factor by pressing ■ NUM and editing `NUMZOOM` (the default zoom factor is 4).

### *Example*

Scroll down in the `x` column, highlight the value `.3`, and press **ZOOM**. Select `Out` and press **OK**. The table is recomputed so that `.3` is still highlighted, but the step size is .4 instead of .1:

| x |
|---|
| -.9 |
| -.5 |
| -.1 |
| .3 |
| .7 |
| 1.1 |

`Decimal` sets the starting value `NUMSTART` to 0 and the step size `NUMSTEP` to .1 units (the default settings).

`Integer` sets the starting value `NUMSTART` to 0 and the step size `NUMSTEP` to 1 unit.

`Trig` sets the starting value `NUMSTART` to 0 and the step size `NUMSTEP` to approximately $\pi/24$ units. If the angle measure mode is *degrees*, then the `NUMSTEP` is 7.5 degrees.

`Un-zoom` is an "undo" key for zoom; it resets the table to its last settings.

# 9. Special VIEWS

VIEWS offers a choice of special viewing screens:

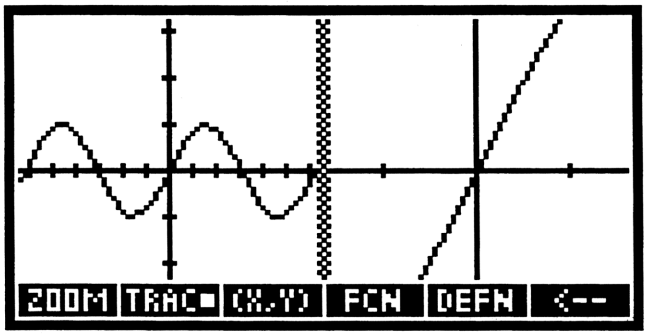
```
Plot-Detail
Plot-Table
Overlay Plot
Auto Scale
Decimal
Integer
Trig
```

### *Split Screen—Two Graphs*

Plot-Detail gives you a vertically split screen with two copies of your graph on either side of a vertical divider down the middle of the screen. It allows you to see a "before" and "after" view of the graph of a function.

Press MENU to get all the usual tools. If you press ZOOM and select a zoom option, the left graph remains unchanged, but the right graph is re-plotted at the new window settings. You can trace and watch dual cross-hairs move simultaneously on both graphs. Then use ▒▒▒ to make the new graph appear on both halves of the screen—in preparation for yet another zoom. And you can repeat this process as many times as you wish!

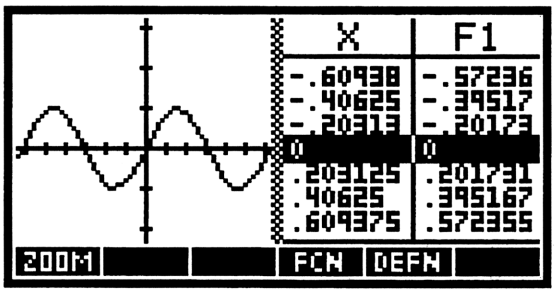
For example, if you graph F1(X)=SIN(X) in the default viewing window, then press VIEWS and select Plot-Detail, you can ZOOM In to see these two graphs, side-by-side:



### *Split Screen—Graph and Table*

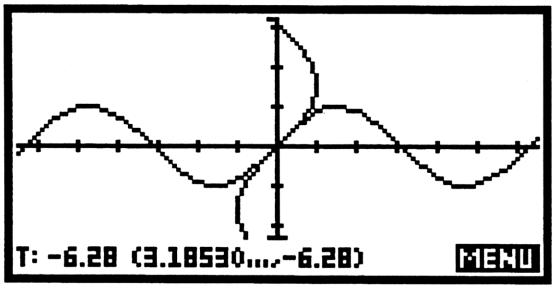
Plot-Table gives you a vertically split screen with a graph on the left and a table of values on the right, allowing you to see both the PLOT and NUMERIC views of your function. The trace crosshairs on the graph and the highlight bar in the table move simultaneously, over the same points.

For example, if you graph F1(X)=SIN(X) in the default viewing window, then press [VIEWS] and select Plot-Table, you will see the graph and table, side-by-side:




### *Overlaying One Graph on Another*

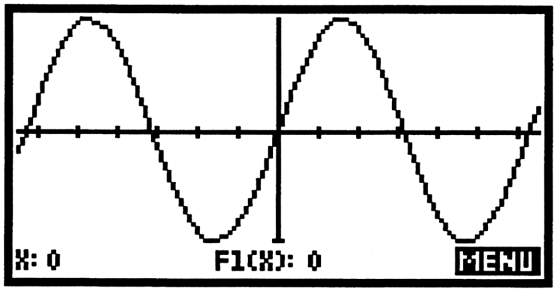
Overlay Plot will plot any graph over your last one. For example, if you plot F1(X)=SIN(X) in the default viewing window, but then press [LIB] and switch from Function to Parametric, you can use Overlay Plot (with the same window settings) to overlay the graph of X1(T)=SIN(T)
Y1(T)=T
over the old graph, to show the inverse relation:



### *Automatic Scaling*

Scroll down to Auto Scale and press OK or ENTER. Auto Scale will *automatically* scale the vertical range for you. It computes a sample of the values of the function for the XRNG and then sets the YRNG automatically to include the extreme $y$-values.

For example, if you plot F1(X)=SIN(X) at the default settings and then press VIEWS and select Autoscaling, you obtain the following graph:




### *Special Preset Zoom Windows*

Decimal sets the "tick" marks along the $x$-axis to be one unit apart (i.e. each pixel width = .1 units). Note that this effectively sets the viewing window back to its *default* ranges [-6.5,6.5]x[-3.1,3.2].

Integer sets the "tick" marks along the $x$-axis to be ten units apart (i.e. each pixel width = 1 unit).

Trig sets the "tick" marks along the $x$-axis to be approximately $\pi/2$ units apart, and each pixel width is approximately $\pi/24$ units. If the angle measure mode is *degrees*, then Trig sets the "tick" marks along the $x$-axis to be 90 degrees apart, and each pixel width is is 7.5 degrees.

# 10. Parametric Equations

Press [LIB], highlight Parametric, and press **START**. This automatically "presses" [SYMB], and you'll see a title bar, PARAMETRIC SYMBOLIC VIEW, with a list of your parametric equations. There are 10 dedicated pairs of parametric equation variables, X1, Y1, X2, Y2, ..., X9, Y9, X0, Y0. You can use the directional arrows ▲ and ▼ to scroll through the entire list.

### *Independent Variable Key*

When Parametric is activated, [X,T,θ] provides the variable T.

### *SYMB Menu*

When you press [SYMB], the menu is **EDIT** **CHK** **T** **SHOW** **EVAL**.

**EDIT** sends the highlighted formula to the Editline where you can edit it. Press **OK** or [ENTER] to confirm the edited version; press **CANCL** or [ON] to restore the original.

**CHK** is a "toggle" that selects or unselects the highlighted equation. You can select any or all pairs of parametric equations X1, Y1, ..., X0, Y0.

**T** is simply another [T] key for typing convenience.

**SHOW** will show the highlighted parametric equation in typeset, "textbook" format (just as **SHOW** does on the HOME screen).

**EVAL** will evaluate any other variables (except the independent variable T) or equations used in the formula of the highlighted parametric equation.

Use [DEL] to erase the highlighted pair of parametric equations; use [CLEAR] to erase *all* the parametric equations.

## *Plotting Graphs and Making Tables for Parametric Equations*

Example: $x(t) = t\cos t$ and $y(t) = t\sin t$ for $0 \le t \le 2\pi$

Highlight X1(T)= and type [X,T,θ] [*] [COS] [X,T,θ] [ENTER]. Highlight Y1(T)= and type [X,T,θ] [*] [SIN] [X,T,θ] [ENTER]. You should now see

√X1(T)=T*COS(T)
√Y1(T)=T*SIN(T)

The √ indicates that X1(T) and Y1(T) are selected for graphing or tabulating. Note that parametric equations are checked in pairs; when you select/deselect one member of the pair, the other is also selected/deselected.

Press [■] [SYMB] to get the PARAMETRIC SYMBOLIC SETUP screen, where you can set the angle measure mode for your parametric equations.

> ☞ *This angle measure mode is distinct from the one used by your HOME screen for computations.*

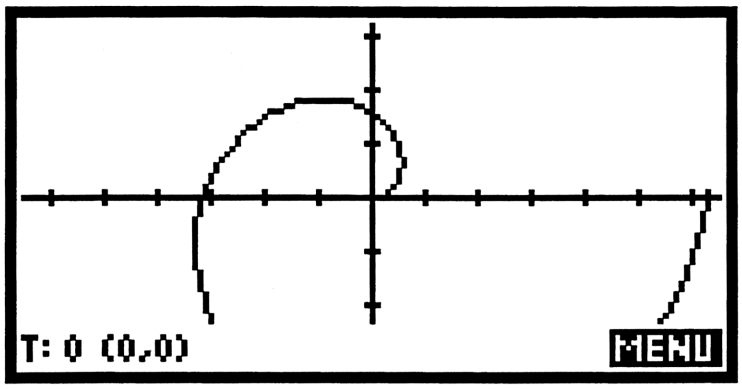
If it is not already indicated, [RADIAN] radian mode for this example. Then press [SYMB] to return to the list of parametric equation formulas.

[■] [PLOT] brings you to the PARAMETRIC PLOT SETUP screen. Here you'll see your window settings for XRNG and YRNG. Since both $x$ and $y$ are considered functions of an independent variable ($t$), you also see settings for the parameter T: TRNG is the domain of the parameter T; and TSTEP is the increment size used to step through the values for T.

To reset all the plot settings, so that the center of the screen is at the origin, coordinate axes are shown, with each axis tick representing one unit, and each pixel valued at 0.1 unit, press [CLEAR]. The default TRNG is [0,12], with a TSTEP of 0.1. The default XRNG is [-6.5, 6.5]; the default YRNG is [-3.1, 3.2].

To change the upper limit of the TRNG to $2\pi$, use the directional arrows to highlight 12 and type [2] [■] [π] [ENTER]. The decimal approximation of $2\pi$ is automatically calculated and used to fill in the slot.

Pressing PLOT now displays the graph traced by X1(T)=T*COS(T) and Y1(T)=T*SIN(T) in the default viewing window:




Both the value of the parameter T and the coordinates (X1(T), Y1(T)) are shown as you trace the curve with ◀ and ▶. You can trace beyond the original domain in either direction.

Press MENU to see the rest of the menu.

ZOOM brings up all the same zoom features found for Function (for a description, see Section 7 on working with graphs).

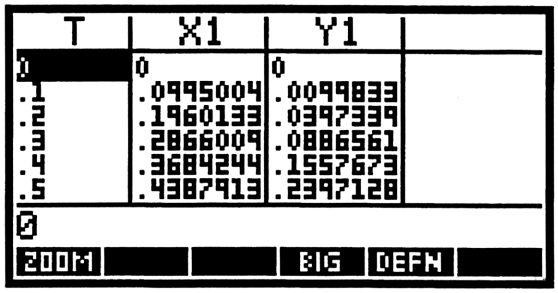
TRACE can be toggled on or off. When TRACE is off, then (X,Y) will show the coordinates of your "free-floating" crosshairs. When TRACE is back on, then (X,Y) will show both T and the coordinates of the corresponding point on the curve again.

DEFN shows you the formula for the currently traced parametric curve. When more than one parametric curve is plotted, the directional arrows ▲ and ▼ will move the crosshairs from curve to curve.

Press MENU again to remove both the menu labels and the coordinates. Pressing any of the menu keys will bring the menu labels back again.

Pressing ■ NUM brings you to the PARAMETRIC NUMERIC SETUP screen. To reset all the numeric table settings, so that the starting value is 0 and values are automatically incremented in steps of 0.1, press CLEAR.

NUM now displays a table:




The same ZOOM features are available here as in Function (see Section 8 on working with tables).

BIG changes the font size used for displaying the table.

DEFN shows you Independent Variable T or the formula for the parametric equation, depending on which column you have highlighted.

Press VIEWS to get a menu of special viewing screens:

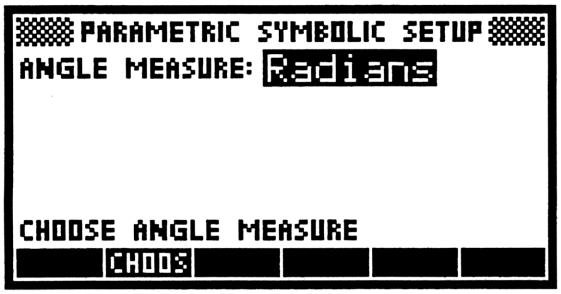
Plot-Detail
Plot-Table
Overlay Plot
Auto Scale
Decimal
Integer
Trig

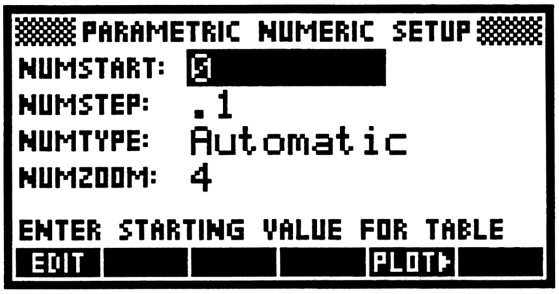
Plot-Detail gives you a vertically split screen with copies of your graph on either side of a divider, allowing a "before" and "after" view of the graph. Plot-Table gives you a vertically split screen with a graph on the left and a table of values on the right of a divider. The trace crosshairs on the graph and the highlight bar in the table move simultaneously over the same points.

For a description of Overlay Plot, Auto Scale, Decimal, Integer, and the Trig that is usable with Parametric, see Section 9 on special views.

## *Guide to PARAMETRIC SETUP Screens*

(SYMB) brings you to PARAMETRIC SYMBOLIC SETUP, where you set the angle measure mode for working with parametric equations.

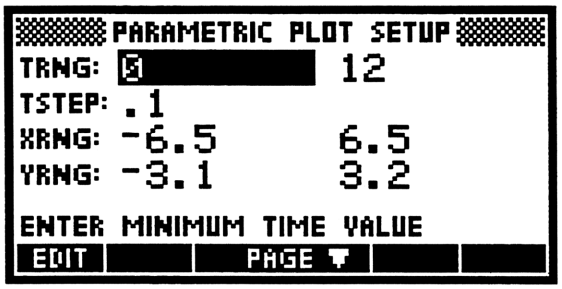


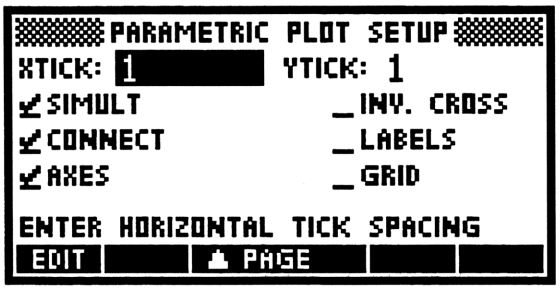




(NUM) brings you to PARAMETRIC NUMERIC SETUP, where you set up parameters for building a table of values for parametric equations.

| | |
|---|---|
| NUMSTART: | the starting value for T |
| NUMSTEP: | the step value (increment) for T |
| NUMTYPE: | Automatic to have the HP 38G generate values for T |
| | Build Your Own lets you fill in the values for T |
| NUMZOOM: | the zoom factor for your table |

(PLOT) brings you to PARAMETRIC PLOT SETUP, where you can set the dimensions of the *viewing window* for graphing and the modes that control how graphs are displayed. There are two pages of settings here; you move between the two screens with PAGE▼ and ▲PAGE.



On the first page of the PARAMETRIC PLOT SETUP are your window settings:

| | |
|---|---|
| TRNG: | TMIN and TMAX (minimum and maximum values of T) |
| TSTEP: | increment size used to step through the values of T |
| XRNG: | XMIN and XMAX (left and right edges of the viewing window) |
| YRNG: | YMIN and YMAX (lower and upper edges of the viewing window) |

To change a highlighted setting, either type in the value you want or press EDIT and edit the current setting. When a choice of options is available, a CHOOS key appears, which gives you a menu box of available choices. Use ▲ and ▼ to select the option you want. In all cases, you press OK or ENTER to make the change, or CANCL or ON if you change your mind. If you press DEL the setting is automatically changed to a default value.

The second page of the PARAMETRIC PLOT SETUP has the settings for the tick marks on the axes as well as "check blanks" for your graphing modes:

| | |
|---|---|
| XTICK: | the spacing of the marks on the $x$-axis |
| YTICK: | the spacing of the marks on the $y$-axis |
| SIMULT | check for simultaneous graphing or don't for sequential |
| CONNECT | check for connected graphing or don't for "dot" mode |
| AXES | check to show the $x$-axis and $y$-axis |
| INV. CROSS | check for inverted "crosshairs" (show white on dark) |
| LABELS | check to have axes labeled with their ranges |
| GRID | check to have lattice points plotted (points that line up with the tick marks on both axes) |

A CHK key allows you to toggle on or off any of the plot mode settings. The default values for all plot settings are shown in the screens illustrated.

# 11. Polar Equations

Press [LIB], highlight Polar, and press **START**. This automatically "presses" [SYMB] and shows the title bar, POLAR SYMBOLIC VIEW, with a list of your polar equations. There are 10 dedicated polar equation variables R1, R2, R3, ..., R9, R0. You can use ▲ and ▼ to scroll through the entire list.

### *Independent Variable Key* [X,T,θ]

When Polar is activated, [X,T,θ] provides the variable θ.

### *SYMB Menu*

When you press [SYMB], the menu is **EDIT** **☑CHK** **θ** **SHOW** **EVAL**.

**EDIT** sends the highlighted formula to the Editline where you can edit it. Use **OK** or [ENTER] to confirm the edited version; **CANCL** or [ON] to restore the original.

**☑CHK** is a "toggle" that selects or unselects the highlighted equation. Any or all of the polar equations R1, R2, ..., R9, R0 can be selected at any time.

**θ** is simply another θ key for typing convenience.

**SHOW** will show the highlighted polar equation in typeset "textbook" format (just as **SHOW** works on the HOME screen).

**EVAL** will evaluate any other variables (except the independent variable θ) or polar equations used in the formula of the highlighted polar equation.

Use [DEL] to erase a highlighted polar equation; use [CLEAR] to *erase all* the polar equations.

## *Plotting Graphs and Making Tables for Polar Equations*

Example: Consider $r(\theta) = 3\sin(2.5\theta)$, for $0 \le \theta \le 4\pi$. Highlight R1(θ)= and type 3 * SIN 2 • 5 X,T,θ ENTER. You should see: √R1(θ)=3*SIN(2.5*θ) The √ indicates that R1(θ) is selected for graphing or making a table.

Press ■ SYMB to get the POLAR SYMBOLIC SETUP screen, where you can set the angle measure mode for your polar equations.

> ☞ *NOTE: This angle measure mode is distinct from the one used by your HOME screen for computations.*

If it is not already indicated, RADIAN radian mode for the purposes of this example. Then press SYMB to return to the list of polar equation formulas.

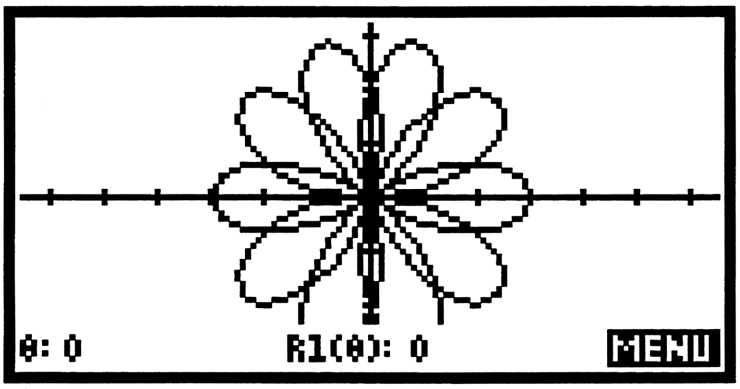
■ PLOT brings you to the POLAR PLOT SETUP screen, where you will see your window settings for XRNG and YRNG. Since the radius, $r$, is considered a function of the polar angle, $\theta$, you also see settings for θ:

θRNG is the domain of the angle θ.
θSTEP is the increment size used to step through the values for θ.

To reset all the plot settings, so that the center of the screen is at the origin, coordinate axes are shown, with each axis tick representing one unit, and each pixel valued at 0.1 unit, press CLEAR. The default θRNG is $[0,2\pi]$, with a θSTEP of $\pi/24$. The default XRNG is [-6.5, 6.5]; the default YRNG is [-3.1, 3.2].

To change the upper limit of the θRNG to $4\pi$, use the directional arrows to highlight 6.28318..., and type 4 ■ π ENTER. The decimal approximation

PLOT now displays the graph of R1(θ)=3*SIN(2.5*θ) in the default viewing window:




The value of the angle θ and the radius R1(θ) appear as you trace the curve with ◀ and ▶. You can trace beyond the original domain in either direction.

Press MENU to see the rest of the menu:

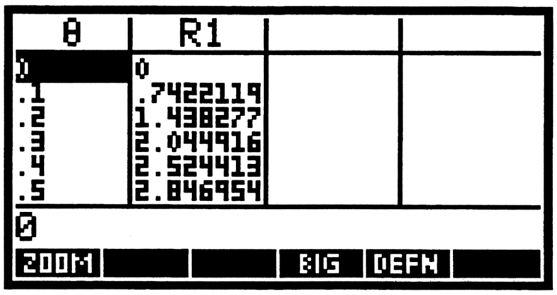
ZOOM offers the same zoom features as does Function (see Section 7).

TRACE can be toggled on or off. When TRACE is off, then CHAR will show the rectangular or Cartesian $(x,y)$ coordinates of your "free-floating" crosshairs. When TRACE is back on, the CHAR will show the polar coordinates θ and R of a point on the curve again.

DEFN shows you the formula for the currently traced polar equation. When more than one polar equation is plotted, the directional arrows ▲ and ▼ will move the crosshairs from curve to curve.

Press MENU again to remove both the menu labels and the coordinates. Pressing any of the menu keys will bring the menu labels back again.

Press ■ NUM brings you to the POLAR NUMERIC SETUP screen. To reset all the numeric table settings, so that the starting value is 0 and values are automatically incremented in steps of 0.1, press CLEAR. Pressing NUM now tabulates values for θ and R1(θ):




The same ZOOM options are offered here as in Function (see Section 8).

BIG changes the font size used for displaying the table.

DEFN shows you either Independent Variable θ or the formula for the polar equation, depending on which column you have highlighted.

Press VIEWS for a menu box of special viewing screens:

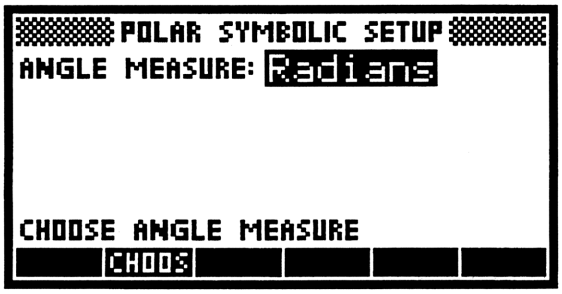
Plot-Detail
Plot-Table
Overlay Plot
Auto Scale
Decimal
Integer
Trig

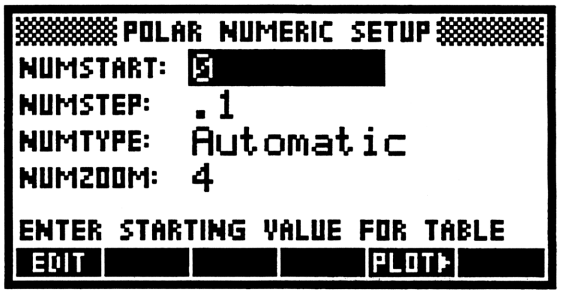
Plot-Detail gives you a vertically split screen with two copies of your graph on either side of a divider, allowing you to see a "before" and "after" view of the graph of a polar equation. Plot-Table gives you a vertically split screen with a graph on the left and a table of values on the right of the divider. The trace crosshairs on the graph and the highlight bar in the table move simultaneously, showing you the same point.

See Section 9 for a description of Overlay Plot, Auto Scale, Decimal, Integer, and the Trig that can also be used with Polar.

## *Guide to POLAR SETUP Screens*

■SYMB brings you to POLAR SYMBOLIC SETUP, where you set the angle measure mode for working with polar equations.

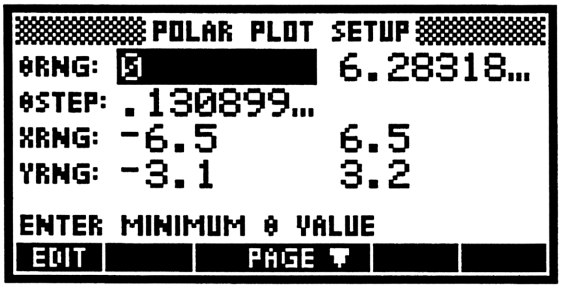


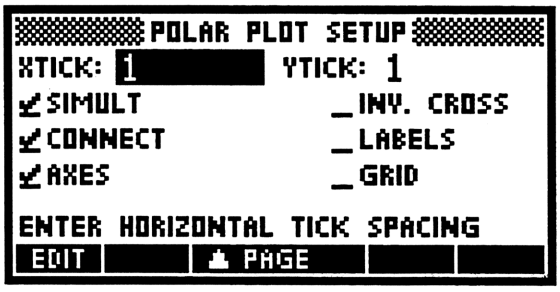




■NUM brings you to POLAR NUMERIC SETUP, where you set up parameters for building a table of values for polar equations:

| | |
|---|---|
| NUMSTART: | the starting value for θ |
| NUMSTEP: | the step value (increment) for θ |
| NUMTYPE: | Automatic to have the HP 38G generate values for θ |
| | Build Your Own lets you fill in the values for θ |
| NUMZOOM: | the zoom factor for your table |

■PLOT brings you to POLAR PLOT SETUP, where you can set the dimensions of the *viewing window* for graphing and the modes that control how graphs are displayed. There are two pages of settings here; you move between the two screens with ▼PAGE and ▲PAGE.



On the first page of the POLAR PLOT SETUP are your window settings:

| | |
|---|---|
| θRNG: | θMIN and θMAX (the minimum and maximum values of θ) |
| θSTEP: | the increment size used to step through the values of θ |
| XRNG: | XMIN and XMAX (left and right edges of the viewing window) |
| YRNG: | YMIN and YMAX (lower and upper edges of the viewing window) |

To change a highlighted setting, you can either type in the value you want or press EDIT and edit the current setting. When a choice of options is available, a CHOOS key comes up, and pressing it gives you a menu box of available choices. Use the directional arrows ▲ and ▼ to select the option you want. In all cases, you press OK or ENTER to make the change and CANCL or ON if you change your mind. If you press DEL, the setting is automatically changed to a default value.

The second page of the POLAR PLOT SETUP has the settings for the tick marks on the axes as well as "check blanks" for your graphing modes:

| | |
|---|---|
| XTICK: | the spacing of the marks on the $x$-axis |
| YTICK: | the spacing of the marks on the $y$-axis |
| SIMULT | check for simultaneous graphing or don't for sequential |
| CONNECT | check for connected graphing or don't for "dot" mode |
| AXES | check to show the $x$-axis and $y$-axis |
| INV. CROSS | check for inverted "crosshairs" (show white on dark) |
| LABELS | check to have axes labeled with their ranges |
| GRID | check to have lattice points plotted (points that line up with the tick marks on both axes) |

A CHK key allows you to toggle on or off any of the plot mode settings. The default values for all plot settings are shown in the screens illustrated.

# 12. Sequences

Press [LIB], highlight Sequence, and press **START**. This automatically "presses" [SYMB], so you'll then see a title bar, SEQUENCE SYMBOLIC VIEW, with a list of your sequence definitions. There are 10 dedicated sequence variables, U1, U2, ..., U9, U0. You can use ▲ and ▼ to scroll through the entire list. To allow recursive definitions, you will see "slots" for specifying the first one or two terms of a sequence.

### *Independent Variable Key,* [X,T,θ]

When Sequence is activated,pressing [X,T,θ] provides the variable N.

### *SYMB Menu*

Pressing [SYMB] offers the menu items **EDIT** **☑CHK** **SHOW** and **EVAL**.

**EDIT** sends the highlighted formula or term to the Editline where you can edit it. Press **OK** or [ENTER] to enter the edited version and press **CANCL** or [ON] to restore the original.

**☑CHK** is a "toggle" that selects or unselects the highlighted sequence. Any or all sequences U1, U2, ..., U0 can be selected at any time.

**SHOW** displays the highlighted item in "textbook" format (just as in HOME).

**EVAL** will evaluate all sequence definitions and variables (except the independent variable N) used in the selected sequence. Also, when a sequence formula line is highlighted, some menu keys offer typing aids. For example, upon highlighting U1(N)=, you'll see **(N-2)**, **(N-1)**, **N**, and **U0**.

To *erase* a highlighted sequence formula or term, press [DEL]. To *erase all the sequences*, press [CLEAR] .

### *Plotting Graphs and Making Tables for Sequences*

Perhaps the simplest kind of sequence is one where a formula describes the $N$th term as a function of $N$. For example, the geometric sequence

$$1, \frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \ldots$$

can be described in "closed form" by the formula $U_N = \frac{1}{2^{N-1}}$

To examine this sequence, use ▲ and ▼ to highlight U1(N)= and then type 1 / 2 $x^y$ ( X,T,θ − 1 ENTER. You should see:

√U1(1)=1
√U1(2)=.5
√U1(N)=1/2^(N-1)

The √'s indicate that the sequence U1 is selected for graphing or making a table. Note how the values for the first two terms U1(1) and U1(2) are automatically computed and displayed.

Press ■ SYMB to get the SEQUENCE SYMBOLIC SETUP screen, where you can set the angle measure mode for sequences, if necessary. If it is not already selected, RADIAN radian mode for this example.

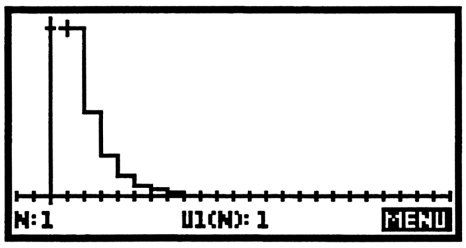
☞ *NOTE: This angle measure mode is distinct from the one used by your HOME screen for computations.*

Press SYMB to return to the list of sequences, and then ■ PLOT to go to the SEQUENCE PLOT SETUP screen. Here are your window settings for XRNG and YRNG. NRNG is the domain (in positive integers) of the index, N.

To reset all the sequence plot settings, so that the coordinate axes are shown, each axis tick represents 1 unit, and each pixel is valued at 0.1 unit, press CLEAR. The default NRNG is the set of positive integers 1, 2, 3,... ,24. The default XRNG is [-2, 24]; the default YRNG is [-2, 10.6].

Since $\frac{1}{2^{N-1}} \leq 1$ for all positive integers $N$, set the YRNG to [-.2, 1.06].

The default sequence plot type (SEQPLOT:) is StairStep. Press PLOT now to see a stairstep plot of U1(N)=1/2^(N-1) in the default viewing window.




Both the value of the index, $N$, and the value of the $N$th term, U1(N), are shown as you trace the stairstep curve with ◀ and ▶. You can trace beyond the original upper limit of $N$ but you cannot trace below $N = 1$.

Press MENU to see the rest of the menu:

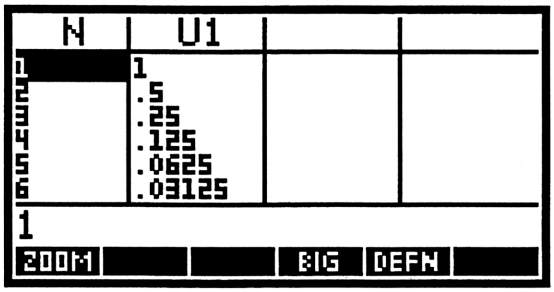
ZOOM brings up all the same zoom features found for Function (see section 7 on working with graphs for a description).

TRACE can be toggled on or off. When TRACE is off, then (X,Y) will show the coordinates of your "free-floating" crosshairs. When TRACE is back on, (X,Y) will show both N and the value of the $N$th term, U1(N), on the stairstep curve again.

DEFN shows you the formula for the currently traced sequence. When more than one sequence is plotted, the directional arrows ▲ and ▼ will move the crosshairs from stairstep to stairstep.

Press MENU again to remove both the menu labels and the coordinates. Pressing any of the menu keys will bring the menu labels back again.

Press ■ NUM brings you to the SEQUENCE NUMERIC SETUP screen. To reset all the numeric table settings, so that the starting value is 0 and values are incremented in steps of 1, press CLEAR. Now NUM will display a table of values for N and U1(N):




The same ZOOM features are available here as in Function (see Section 8, Working With Tables).

BIG changes the font size used for displaying the table.

DEFN shows you Independent Variable T or the formula for the parametric equation, depending on which column you have highlighted.

Press VIEWS to get a choice of special viewing screens:

Plot-Detail
Plot-Table
Overlay Plot
Auto Scale

Plot-Detail gives you a vertically split screen with two copies of your graph on either side of a vertical divider, so you see a "before" and "after" view of the sequence'sgraph. Plot-Table gives you a vertically split screen with a graph on the left and a table of values on the right of a vertical divider down the middle of the screen. The trace crosshairs on the graph and the highlight bar in the table move simultaneously over the same point. See Section 9 on Special Views for more on Overlay Plot, Auto Scale.

### *Series*

A *series* is a sequence of partial sums. For example, the $N$th term of the harmonic series is

$$\sum_{J=1}^{N} \frac{1}{J}$$

Press [SYMB] and highlight U2(N). Press [CHARS] for a menu of special characters—handy for retrieving the symbol you'll need. Use the directional arrows to highlight Σ (fourth character from the left, second row). Then press [▓▓] to see the symbol "echoed" to the Editline: Σ

And key in the rest of the series: [(] [A...Z] [J] [CHARS] = [▓▓] [1] [,] [A...Z] [N] [,] [1] [/] [A...Z] [J] [ENTER].

Now you can look at a table of values or a plot of the partial sums—just like any other sequence.

### *Iterative Sequences*

You can also define a sequence iteratively or recursively with the HP 38G. For example, a certain sequence derived from Newton's Method can be defined iteratively as:

$$u_1 = 2, \qquad u_n = \frac{u_{n-1}}{2} + \frac{1}{u_{n-1}}$$

We can define it just this way on the HP 38G. In [SYMB], highlight U3(1) and enter 2 for it. Then skip U3(2) and enter the formula for U3(N):

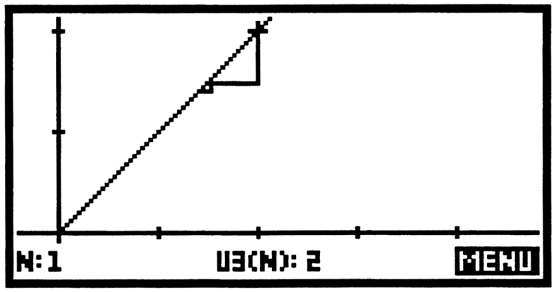
U3(N)=U3(N-1)/2+1/U3(N-1)

Using [NUM], you can see how quickly this sequence converges to $\sqrt{2}$.

### *Cobweb Plots*

Iterative sequences are nicely displayed using a *cobweb plot*. In a cobweb plot, the first term of a sequence $u_1$ is located as the point $(u_1,u_1)$ on the line $y = x$. This point is connected with a vertical line segment to $(u_1,u_2)$, which is, in turn, connected with a horizontal line segment to $(u_2,u_2)$. This process continues, forming a web of line segments connecting $(u_2,u_2)$ to $(u_3,u_3)$ to $(u_4,u_4)$, etc. If the sequence converges, the web closes in on a single point.

For a cobweb plot of the sequence just defined, first press SYMB and select U3 (and deselect all other sequences). Press ■ PLOT for the SEQUENCE PLOT SETUP. Highlight SEQPLOT and CHOOS Cobweb. Set the viewing window to [-.4,4.8] x [-.4,2.12] and press PLOT to see the cobweb plot. (Note, also, that if you trace the cobweb plot near the point of convergence, you can ZOOM In to see more detail.)




### *Example*

Enter this additive Fibonacci sequence:

```
U4(1)=1
U4(2)=1
U4(N)=U4(N-1)+U4(N-2)
```

And this Fibonacci sequence of ratios:

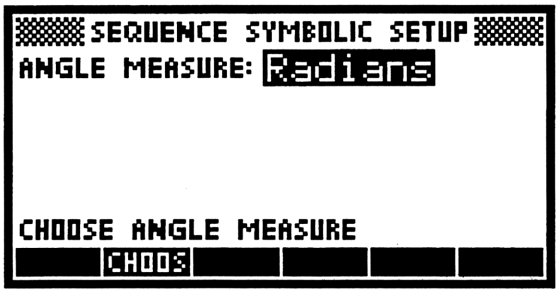
```
U5(1)=1
U5(2)=1
U5(N)=U4(N)/U4(N-1)
```

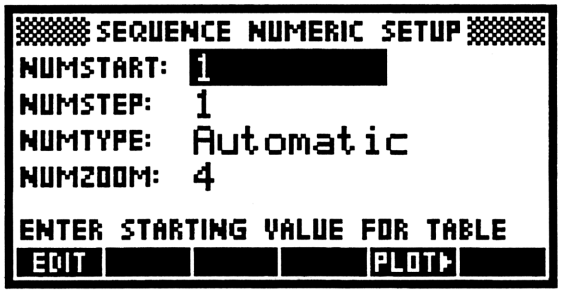
The U5 sequence converges at the golden ratio $\frac{1+\sqrt{5}}{2}$

You can examine its behavior numerically via NUM or graphically via PLOT.

## *Guide to SEQUENCE SETUP Screens*

■ SYMB brings you to SEQUENCE SYMBOLIC SETUP, where you can set the angle measure mode for working with sequences, if necessary.

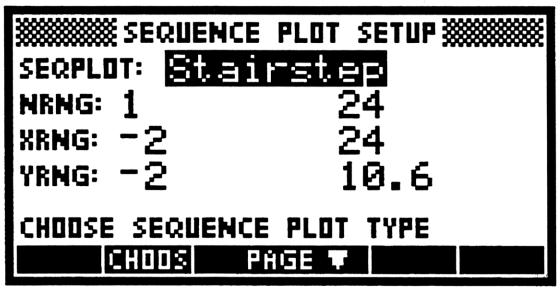


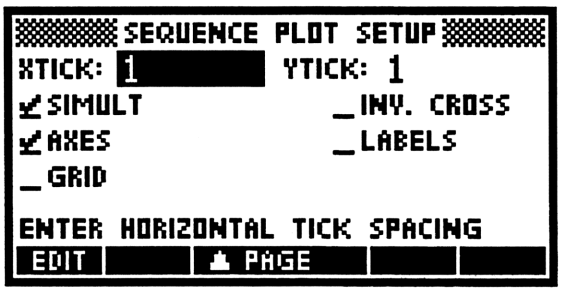




■ NUM brings you to SEQUENCE NUMERIC SETUP, where you set up parameters for building a table of values for parametric equations.

NUMSTART: the starting value for N
NUMSTEP: the step value (increment) for N
NUMTYPE: Automatic to have the HP 38G generate values for N
Build Your Own lets you fill in the values for N
NUMZOOM: the zoom factor for your table

■ PLOT brings you to SEQUENCE PLOT SETUP, where you set the dimensions of the *viewing window* for graphing and the modes that control how graphs are displayed. There are two pages of settings here; you move between the two screens with ▼PAGE and ▲PAGE. The default values for all the plot settings are shown in the screens illustrated.



On the first page of the SEQUENCE PLOT SETUP are window settings:

SEQPLOT: CHOOS between Stairstep and Cobweb
NRNG: NMIN and NMAX (minimum and maximum values of index N)
XRNG: XMIN and XMAX (left and right edges of the viewing window)
YRNG: YMIN and YMAX (lower and upper edges of the viewing window)

To change a highlighted setting, you can either type in the value you want or press EDIT and edit the current setting.

When a choice of options is available, a CHOOS key comes up, and pressing it gives you a menu box of available choices. Use the directional arrows ▲ and ▼ to select the option you want. In all cases, you press OK or ENTER to make the change and CANCL or ON if you change your mind. If you press DEL the setting is automatically changed to a default value.

The second page of the SEQUENCE PLOT SETUP has the settings for the tick marks on the axes and "check blanks" for your graphing modes:

| | |
|---|---|
| XTICK: | the spacing of the marks on the $x$-axis |
| YTICK: | the spacing of the marks on the $y$-axis |
| SIMULT | check for simultaneous graphing or don't for sequential |
| AXES | check to show the $x$-axis and $y$-axis |
| GRID | check to have lattice points plotted |
| INV. CROSS | check for inverted "crosshairs" (show white on dark) |
| LABELS | check to have axes labeled with their ranges (points that line up with the tick marks on both axes) |

A ☑CHK key allows you to toggle on or off any of the plot mode settings.

# 13. Solving Equations

The Solve ApLet lets you find roots of expressions and solve equations. To activate it, press [LIB], highlight Solve, and press START. A title bar, SOLVE SYMBOLIC VIEW, appears, with a list of your expressions/equations. You get 10 dedicated variables, E1, E2, ..., E9, E0 (use ▲ and ▼ as needed).

### *Independent Variable Key* [X,T,θ]

When Solve is activated, [X,T,θ] provides the variable X. However, you can use any real variables you wish in your equations.

### *SYMB Menu*

When you press [SYMB], the menu is EDIT ☑CHK =  SHOW EVAL.

EDIT sends the highlighted expression/equation to the Editline where you can edit it. Press OK or [ENTER] to enter the edited version and press CANCL or [ON] to restore the original.

☑CHK is a "toggle" that selects or unselects the highlighted item. Note that, unlike the Function, Parametric, Polar, and Sequence ApLets, only one of the expressions/equations E1, E2, ..., E9, E0 can be selected at once.

= is a key provided for typing convenience.

SHOW will show the highlighted expression/equation in typeset, "textbook" format (just as SHOW works on the HOME screen).

EVAL will evaluate the expression/equation for all values of the variables used in the highlighted expression/equation.

[DEL] erases the *highlighted* expression/equation; [CLEAR] erases all of them.

### *Analyzing an Expression in One Variable*

Highlight E1 and type: A...Z X $x^y$ 2 − 3. You should see: √E1: X^2-3
Now press NUM to go to the SOLVE NUMERIC VIEW, where you can substitute a value for X. The HP 38G will use this value as an initial seed to find a *root* of this expression—a value for X such that X^2-3 is *zero*.

Try this: With the slot for X highlighted, type in an initial seed value of 5 and press OK (so that you see X: 5). Now press SOLVE. The little hourglass annuciator appears briefly, then the solution, X: 1.73205080757

Different roots may be found by changing the seed value. For example, with X: highlighted in the SOLVE NUMERIC VIEW, type -X 5 ENTER SOLVE.
The result is the other root of $X^2 - 3 = 0$: X: -1.73205080757

Some more about the rest of the menu in the SOLVE NUMERIC VIEW:

EDIT allows you to edit the current value of the highlighted variable.

INFO gives you information about the quality of your solution. Press it now and you'll see a box with this data:

```
X:
1.73205080757
Zero
```

The Zero indicates that the displayed value of X is a root (i.e. it satisfies $X^2 - 3 = 0$, to 12-digit accuracy).

Note, however, that there are two other possible messages you can obtain in the INFO box:

A Sign Reversal message indicates that the value of the expression changes sign (positive to negative or vice-versa) when there is a change in the last digit of the displayed value of X. If the expression is that of a continuous function, this means the X-value is within one digit of a root.

An Extremum message generally indicates that the displayed value of X

minimizes the absolute value of the expression, but that no sign reversal has been obtained.

PAGE is a key available in case your expression or equation contains so many variables that you need more than one screen for all of them.

DEFN displays the current expression or equation in typeset form—as SHOW does in the HOME screen.

☞ *When you return to the HOME screen after using the* Solve *ApLet, any real variables used will still have their last values shown in the* SOLVE NUMERIC VIEW. *For example, if you return to the HOME screen now and type* A...Z X ENTER, *you will see* -1.73205080757.

### *Analyzing an Equation with Several Variables*

Another example: Return to the SOLVE SYMBOLIC VIEW via SYMB. Then highlight E2 and type A...Z A $x^y$ 3 − 2 * A...Z B = C $x^y$ 2 + 6 ENTER. You will see this:

```
 E1:X^2-3
√E2:A^3-2*B=C^2+6
```

Notice that the √ has automatically been turned off on E1 because only one equation or expression can be checked at a time.

Use NUM to go to the SOLVE NUMERIC VIEW. There is a slot for each of the three variables in the equation. Enter these values:

```
A:  3
B:  4
C:  -5
```

You can solve for any variable—say, B—using the other variables' values: Highlight B: 4, and press SOLVE to see

```
A:  3
B:  -2.00000000001
C:  -5
```

The value originally stored in B was used as a seed for the numerical root finder (note the effects of round-off precision).

### *Using* PLOT *with the Solve ApLet*

For best results, you should use PLOT on an equation that has been simplified so that all variables appear only on the left side of the equation. For example, you can take the equation

√E2: A^3-2*B=C^2+6

and EDIT it to be √E2: A^3-2*B-C^2-6=0

or, even simpler: √E2: A^3-2*B-C^2-6

because, in this form—where the right-hand side of the equation is =0—it is not necessary to include it at all.

Next, press NUM and fill in

A: 3
B: 4
C: -5

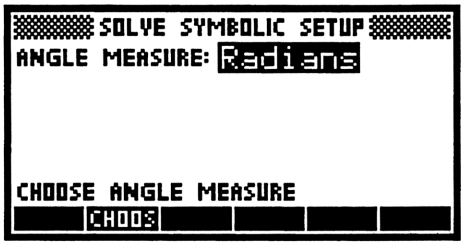
Now highlight, say, B:, and you can press PLOT to see the left-hand side of the equation *plotted as a function* of B. That is, the horizontal axis represents B as independent variable, with $A = 3$ and $C = -5$. Thus, the plot is actually

$$Y = 3^3 - 2B - (-5)^2 - 6 \qquad \text{or} \qquad Y = -2B - 4$$

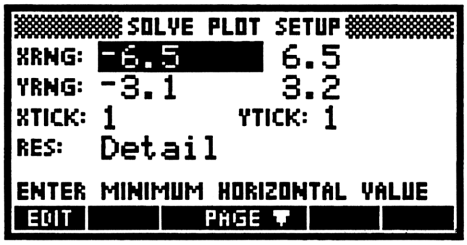
Sure enough—the plot shows the graph of a line. If you trace the graph, you will see values of B and the expression E2(B) shown. And if you press NUM while tracing, you will see the current trace value of B substituted (that is, the table will have highlighted the row corresponding to the last location of the crosshairs).

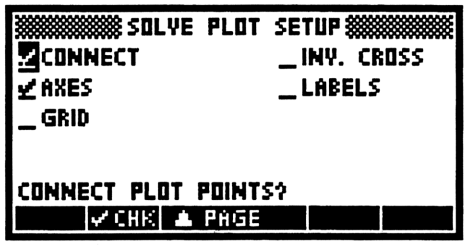
## *Guide to SOLVE SETUP Screens*

▀SYMB brings you to SOLVE SYMBOLIC SETUP, where you set the angle measure mode for working with equations.




There is no SOLVE NUMERIC SETUP. However, ▀PLOT brings you to SOLVE PLOT SETUP, which is identical to the FUNCTION PLOT SETUP, allowing you to set up a *viewing window* for graphing the values of an expression with respect to one variable. There are two pages of settings here; you move between the two screens with the ▀PAGE▼ and ▀▲PAGE keys.




To set the default settings for plotting, press CLEAR.

On the first page of the SOLVE PLOT SETUP are your window settings:

XRNG: XMIN and XMAX (left and right edges of the viewing window)
YRNG: YMIN and YMAX (lower and upper edges of the viewing window)
XTICK: the spacing of the marks on the $x$-axis
YTICK: the spacing of the marks on the $y$-axis
RES: plot resolution (Faster plots every other pixel; Detail plots every pixel)

To change a selected setting, you can either type in the value you want or press ▀EDIT and edit the current setting.

When a choice of options is available, a CHOOS key comes up; pressing it gives you a menu box of available choices. Use the directional arrows ▲ and ▼ to select the option you want. In all cases, you press OK or ENTER to make the change; or CANCL or ON if you change your mind.

If you press DEL, the setting is automatically changed to a default value. The default values for all settings (except RES:) are shown in the screens illustrated opposite.

☞ *We strongly suggest that you use* Detail *resolution for most of your graphing work. The gain in accuracy far outweighs any speed benefit gained with* Faster *resolution.*

The second page of the SOLVE PLOT SETUP has "check blanks" for your graphing modes:

| | |
|---|---|
| SIMULT | check for simultaneous graphing or don't for sequential |
| CONNECT | check for connected graphing or don't for "dot" mode |
| AXES | check to show the $x$-axis and $y$-axis |
| INV. CROSS | check for inverted "crosshairs" (show white on dark) |
| LABELS | check to have axes labeled with their ranges |
| GRID | check to have lattice points plotted (points that line up with the tick marks on both axes) |

A ☑CHK key allows you to toggle on or off any of these plot mode settings. (The default settings are shown in the illustrated screens.)

# 14. Working with Complex Numbers

On the HP 38G, the arithmetic keys perform different operations depending on the type of mathematical objects involved. In this section, you'll see how complex numbers are handled by the calculator.

### *Entering Complex Numbers*

You can enter a complex number either as an ordered pair, $(a,b)$, or in algebraic form, $a+bi$.

Enter $2+3i$ as an ordered pair: (2,3)ENTER

```
(2,3)
(2,3)
```

Note how the right parenthesis was added for you.

Enter $-4+5i$ algebraically: -X4+5 A...Z I ENTER

```
-4+5i
(-4,5)
```

Note that `i` is recognized as the complex number `(0,1)`. Note also how, regardless of the form in which you enter a complex number (ordered pair or algebraic), the result is always shown as an ordered pair.

### *Storing Complex Numbers*

There are 10 variables designated for complex numbers: `Z1`, `Z2`, `Z3`, ..., `Z9`, `Z0`. To store a complex number, you must use one of those variable names. For example:

(2,3) STO▶ A...Z Z 1

```
(2,3)▶Z1
(2,3)
```

3 STO▶ A...Z Z 2

```
3▶Z2
3
```

### *Computational Examples Using Complex Numbers*

To try the following examples, you can either type in the complex numbers as shown or use the COPY feature.

Addition:
```
(2,3)+(-4,5)
                (-2,8)
```

Subtraction:
```
(2,3)-(-4,5)
                (6,-2)
```

Multiplication:
```
(2,3)*(-4,5)
              (-23,-2)
```

Division:
```
(1,5)/(2,-3)
                (-1,1)
```

Exponentiation:
```
(0,2)^3
                (0,-8)
```

Modulus (absolute value):
```
ABS(3-4i)
                     5
```

Press MATH and select the Complex menu to find other operations for working with complex numbers.

Argument:
```
ARG((-1,1))
                   135
```

☞ *This is the polar angle, $\theta$, that a ray drawn from the origin to the point makes with the positive $x$-axis. The value will depend on whether your HOME screen is in degree or radian mode (the example uses degree mode).*

Conjugate:
```
CONJ(3-4i)
                (3,4)
```

Real part:
```
RE(3-4i)
                     3
```

Imaginary part:
```
IM(3-4i)
                    -4
```

# 15. Working with Lists

Many HP 38G operations can be applied to entire lists of elements.

### *Entering Lists*

A *list* on the HP 38G is indicated like this, { , , , , }, by braces, with elements separated by commas. For example, to enter a list of the first 6 positive even integers, press {2,4,6,8,10,12ENTER}.
You should see this:

```
{ 2, 4, 6, 8, 10, 12
                    { 2, 4, 6, 8, 10, 12 }
```

Notice how the right brace is added automatically for you.

### *Storing Lists*

There are 10 designated variables for lists: L1, L2, L3, ..., L9, L0. To store a list, you must use one of these variable names. For example, to store the above list, press ANSWER STO A...Z L 1:

```
Ans▶L1
                    { 2, 4, 6, 8, 10, 12}
```

### *List Catalog*

The HP 38G also has a convenient catalog and editor for your ten list variables. Press LIST to see the LIST CATALOG. This scroll-down menu shows all of your lists and their *lengths*. (Every undefined list variable is, by default, an empty list, { }, with Length 0.) If you have not stored any lists other than the above example, you will see:

```
L1  Length 6
L2  Length 0
L3  Length 0
L4  Length 0
L5  Length 0
```

### *List Editor*

With L1 Length 6 highlighted, press EDIT. The title bar shows L1 at the top, and the elements of the list are now displayed vertically with labels indicating their positions:

```
1:  2
2:  4
3:  6
4:  8
5:  10
```

Not all the elements are in view, but you can use ▲ and ▼ to scroll through the list and see each of the elements. Use ▼ to see 6: 12. Notice how he "bottom" of the list is indicated by a horizontal shaded bar.

To edit an element in the list, highlight it and press EDIT. This will copy the element to the Editline, where you can make changes. When you finish, press OK or ENTER—or, if you change your mind, use CANCL or ON.

To replace an element in the list, highlight the position and start typing. The new element appears on the Editline; ENTER completes the replacement.

To insert a new element in the list, highlight the position where you want to insert the element and press INS. (To add an element on the end of the list, highlight the horizontal shaded bar at the end.) The Editline becomes active and you can type in your new entry. When you finish, press OK or ENTER—or, if you change your mind, press CANCL or ON.

To delete an element from the list, just highlight it and press the DEL key.

To delete all the elements from the list (i.e. to make it empty), press CLEAR. A message box will ask you if you are sure you want to clear the list, offering NO and YES keys for your response.

☞ *When you finish editing or examining the list, either press* LIST *again to return to the* LIST CATALOG, *or press* HOME *to return to the HOME screen.*

### *Creating a List in the Catalog*

To store a new list, L2, directly into the LIST CATALOG, press [LIST], highlight L2, and press [EDIT]. You will see L2 in the title bar at the top of the screen and the words Empty List. Simply type in the elements of the new list, pressing [ENTER] after each one.

For example, to enter the list of the first six prime numbers into L2, just type [2][ENTER][3][ENTER][5][ENTER][7][ENTER][1][1][ENTER][1][3][ENTER]. When you finish, press [LIST] again and see that you now have:

```
L1   Length 6
L2   Length 6
L3   Length 0
L4   Length 0
L5   Length 0
```

Try one more example. Enter into list L3 the first 10 positive integers as elements: Press [EDIT], then [1][ENTER][2][ENTER][3][ENTER][4][ENTER][5][ENTER][6][ENTER][7][ENTER][8][ENTER][9][ENTER][1][0][ENTER].

Again, press [LIST] to see the LIST CATALOG:

```
L1   Length 6
L2   Length 6
L3   Length 10
L4   Length 0
L5   Length 0
```

### *Computational Examples Using Lists*

These examples use the lists L1, L2, and L3 that you just stored. To recap:

```
L1 is { 2, 4, 6, 8, 10, 12 }
L2 is { 2, 3, 5, 7, 11, 13 }
L3 is { 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 }
```

When a function is applied to a list, the result is the list of elements obtained by applying the function to each element of the original list.

When an arithmetic operation is performed on two lists, the lists must be of the same length (if they aren't, you will get an `Invalid Dimension` error message). The result is a list whose elements are the *component-wise* results of the operation.

When an arithmetic operation is performed between a *number* and a *list*, then the result is a list obtained by distributing the operation with that number to each element. Go [HOME] and try these examples:

Addition:

```
L1+L2
     { 4, 7, 11, 15, 21, 25 }
L1+5
     { 7, 9, 11, 13, 15, 17 }
```

Subtraction:

```
L1-L2
       { 0, 1, 1, 1, -1, -1 }
L1-8
      { -6, -4, -2, 0, 2, 4 }
```

Multiplication:

```
L1*L2
  { 4, 12, 30, 56, 110, 156 }
L1*3
    { 6, 12, 18, 24, 30, 36 }
```

Division:

```
                                  L2/L1
{ 1, .75, .833333333333, .875, 1.1, 1.08333333333 }
                                  L1/4
                                { .5, 1, 1.5, 2, 2.5, 3 }
```

Negation:

```
                                  -L2
                               { -2, -3, -5, -7, -11, -13 }
```

Exponentiation:

```
                                  L3^L3
{1, 4, 27, 256, 3125, 46656, 823543, 16777216, 387420489, 10000000000}
                                  L1^2
                                { 4, 16, 36, 64, 100, 144 }
                                  2^L1
                             { 4, 16, 64, 256, 1024, 4096 }
```

Reciprocal:

```
                                  L1^-1
      { .5, .25, .166666666666, .125, .1, 8.33333333333E-2 }
```

### *Special List Operations*

Press MATH and select the List menu to find other list operations:

△LIST gives the list of *first differences*:

```
                                  L1^2
                                { 4, 16, 36, 64, 100, 144 }
                                  △LIST(Ans)
                                     { 12, 20, 28, 36, 44 }
```

Notice that △LIST subtracts the first element from the second, the second from the third, and so on, resulting in a list having one less element than the original. Try it again on the last result—to get a list of *second* differences:

```
                                  △LIST(Ans)
                                           { 8, 8, 8, 8 }
```

ΠLIST multiplies all list elements:

```
ΠLIST(L3)
                    3628800
```

ΣLIST sums all list elements:

```
ΣLIST(L3)
                         55
```

POS finds the position of an element:

```
POS(L1, 8)
                          4
```

SIZE finds the length of a list.

```
SIZE(L1)
                          6
```

REVERSE reverses a list's elements:

```
REVERSE(L2)
          { 13, 11, 7, 5, 3, 1 }
```

SORT puts list elements in increasing order:

```
SORT({ 5, 2, -4, 7, 3 })
            { -4, 2, 3, 5, 7 }
```

CONCAT concatenates (joins) two lists:

```
CONCAT(L1, L2)
{ 2, 4, 6, 8, 10, 12, 2, 3, 5, 7, 11, 13 }
```

### *Generating a List*

MAKELIST generates a list by taking an expression involving an index variable, the name of the index variable, and a start, end, and step value for that variable.

For example:

```
MAKELIST(N^2, N, 1, 7, 2)
            { 1, 9, 25, 49 }
```

# 16. Working with Vectors and Matrices

On the HP 38G, the arithmetic keys perform different operations depending on the type of mathematical objects involved. In this section, you'll see how vectors and matrices are handled by the calculator.

### *Entering Vectors and Matrices*

A *vector* on the HP 38G is indicated by brackets, with its components separated by commas, like this: [ , ]

For example, to enter the vector [2,3,4], press: [ 2 , 3 , 4 ENTER]

```
[2, 3, 4
                [2, 3, 4]
```

Notice how the right bracket was added automatically for you.

A *matrix* is entered as a "vector of vectors." For example, to enter the matrix

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

you type in a vector containing each *row vector* of the matrix:

[ [ 1 , 2 ] , [ 3 , 4 ENTER]

```
[[1, 2], [3, 4
        [[1, 2], [3, 4]]
```

Again, notice how the closing right brackets are added for you.

### *Storing Vectors and Matrices*

There are 10 designated variables to be used for storing either vectors and matrices: M1, M2, M3, ..., M9, M0. Here are some examples:

[ 2 , 3 , 4 ] STO▶ A...Z M 1 [2, 3, 4]▶M1

[2, 3, 4]

[ 1 , -X 2 , 1 ] STO▶ A...Z M 2 [1, -2, 1]▶M2

[1, -2, 1]

[ [ 1 , 2 ] , [ 3 , 4 ] ] STO▶ A...Z M 3 [[1, 2], [3, 4]]▶M3

[[1, 2], [3, 4]]

You can also use complex numbers in a vector or matrix:

[ ( 2 , -X 1 ) , ( 2 , 1 ) ] STO▶ A...Z M 5

[(2, -1), (2, 1)]▶M5

[(2, -1), (2, 1)]

### *Matrix Catalog*

The HP 38G has a convenient catalog and editor for your vector and matrix variables. Press MATRIX to see the MATRIX CATALOG, a scroll-down menu of all of your stored vectors and matrices and their dimensions. All these variables have a *default* value of a 1x1 *zero matrix*, [[0]]. So, if you have not stored any other vectors or matrices other than the examples just discussed, you will see this:

```
M1   3 ELEMENT REAL VECTOR
M2   3 ELEMENT REAL VECTOR
M3   2X2 REAL MATRIX
M4   1X1 REAL MATRIX
M5   2 ELEMENT COMPLEX VECTOR
```

14,253.5 ID matrix(20) ⇒ 10,168

13,352.5

## *Matrix Editor*

Vectors and matrices can be displayed and edited in a tabular format somewhat like a "spreadsheet." With M1 highlighted, press **EDIT**. In the first two columns, you should see:

```
M1:  VECTOR
1:   2
2:   3
3:   4
```

You can use ▲ and ▼ to highlight each of the components. The value of the highlighted component is also displayed on the Editline. (If a component is a number with several digits, this allows you to see the entire number.)

To look at the matrix M3 in this format, return to the MATRIX CATALOG by pressing MATRIX again. Then highlight M3 and press **EDIT**. Now all four directional arrows can be used to move around this matrix.

Note that **BIG** is a toggle that alternates between a large and small font sizes. And **GO** is a three-way toggle that controls how the highlight bar automatically advances: **GO→** means the bar automatically advances horizontally to the right; **GO↓** means the bar automatically advances downward; and just **GO** means the bar does not automatically advance.

To edit an entry in a vector or matrix, highlight it and press **EDIT**. This will copy the element to the Editline where you can make changes. When you finish, press **OK** or ENTER, or, if you change your mind, use **CANCL** or ON.

To completely replace an entry in a vector or matrix, you can highlight the position and just start typing. The new entry will appear on the Editline. When you press ENTER it will replace the previous entry.

To insert a new component in a vector, highlight the position where you want to insert the component and press **INS**. A new component, 0, is automatically inserted and highlighted, and you can now edit this component. When you finish, press **OK** or ENTER, or, if you change your mind, use **CANCL** or ON.

To add an element at the end of a vector, highlight the empty space there and press INS (note that this will change the dimension of your vector).

To insert a new row or column within a matrix, highlight where you want to insert and press INS to be prompted for the choice of Row or Column. To add a row on the bottom of a matrix, highlight anywhere in the row of spaces below the matrix and press INS. To add a column to the matrix, highlight any position in the column of spaces to the right the matrix and press INS. (Note: Inserting a row or column will change the dimension of your matrix.)

To delete an entry from a vector, highlight it and press DEL. If you highlight an entry in a matrix and press DEL, you can delete either its Row or Column.

☞ *When you finish editing or examining a vector or matrix, either press* MATRIX *again to return to the* MATRIX CATALOG *or press* HOME *to return to the HOME screen.*

There are two ways to reset a matrix variable (to the default zero matrix, [[0]]): While displaying the matrix in table form in the MATRIX EDITOR, you can press CLEAR. A message box asks you to confirm your intention to clear. Or, if you are in the MATRIX CATALOG and highlight the name of a matrix variable, then pressing DEL has same effect. To reset *all* the matrix variables, simply press CLEAR in the MATRIX CATALOG.

### *Creating a Matrix in the Catalog*

To store a new matrix in M4 directly in the MATRIX CATALOG press MATRIX, highlight M4, and press EDIT. You will now see M4 with the single element, 0. Now just type the entries of the new matrix, pressing ENTER or OK after each one. Use the directional arrow keys to move around. For example, with GO▸ showing, type 8 ENTER (-) 3 ENTER 5 ENTER ▼ (-) 2 ENTER 4 ENTER 1 ENTER. Notice that as soon as you type the first entry of the second row, the rest of the row is filled in with 0's. When you finish, press MATRIX again and see M4 2×3 REAL MATRIX in the catalog.

### *Computational Examples Using Vectors and Matrices*

The following examples use the vectors/matrices M1, M2, M3, M4, and M5 that you just stored: M1 is the 3-element real vector [2, 3, 4]
M2 is the 3-element real vector [1, -2, 1]
M3 is the 2X2 real matrix [[1, 2], [3, 4]]
M4 is the 2X3 real matrix [[8, -3, 5], [-2, 4, 1]]
M5 is the 2-element complex vector [(2, -1), (2, 1)]

A wide variety of arithmetic operations can be performed vectors, matrices, real and complex numbers on the HOME screen. As long as a calculation makes "sense" with respect to the dimensions of the objects involved, the HP 38G will carry it out. These examples will illustrate.

Addition:

```
M1+M2
                          [3, 1, 5]
M4+M4
        [[16, -6, 10], [-4, 8, 2]]
```

Subtraction:

```
M1-M2
                          [1, 5, 3]
```

Negation:

```
-M3
                [[-1, -2], [-3, -4]]
```

Scalar multiplication:

```
5*M1
                         [10, 15, 20]
-2*M3
                [[-2, -4], [-6, -8]]
```

Length (norm) of a vector using ABS:

```
ABS(M1)
                      5.38516480713
```

Use this to find a *unit vector* in the same direction as the original:

```
                          M1/Ans
[.371390676354, .55708614532, .742781352709]
```

Inverse of a matrix using [x⁻¹]:

```
M3^-1
                [[-2,1],[1.5,-.5]]
```

Matrix multiplication:

```
M3*Ans
                    [[1,0],[0,1]]
M3*M
              [[4,5,7],[16,7,19]]
```

Note that if you attempt to multiply M4*M3, you will get an Invalid Dimension error—matrix multiplication is not generally commutative

Squaring a matrix:

```
M3^2
                  [[7,10],[15,22]]
```

### *Dot and Cross Products*

Press [MATH] and select the Matrix menu to find other operations for working with vectors and matrices. Here are some examples:

Dot product of two vectors:

```
DOT(M1,M2)
                                  0
```

A dot product can be calculated for any two vectors of the same dimension.

Cross Product:

```
CROSS([2,3,4],[1,-2,1])
                        [11,2,-7]
```

Note that the cross product can be calculated only for two 3-dimensional vectors (although you can key in 2-dimensional vectors—the HP 38G will assume that they are actually 3-dimensional and that their third components are 0). If the vectors to be "crossed" are not scalar multiples of one another, the cross product gives a vector that is mutually perpendicular to both of the original vectors.

### *Special Operations for Matrices*

SIZE gives the dimension(s) as a list:

```
SIZE(M1)
                {3}
SIZE(M4)
              {2,3}
```

Determinant of a matrix:

```
DET(M3)
                -2
```

Inverse of a matrix:

```
INVERSE(M3)
      [[-2,1],[1.5,-.5]]
```

Trace of a matrix:

```
TRACE(M3)
                 5
```

Transpose of a matrix:

```
TRN(M4)
   [[8,-2],[-3,4],[5,1]]
```

And try this now:

```
Ans*M4▶M6
[[68,-32,38],[-32,25,-11],[38,-11,26]]
```

If you press MATRIX to bring up the MATRIX CATALOG you will find M6 there. Highlight it and press EDIT to view this new matrix in table form.

### *Generating a Matrix*

MAKEMAT generates a matrix by taking an expression involving index variables (I for rows; J for columns) and the number of rows and columns. The result matrix's elements are obtained by evaluating the expression at each possible pair of index values (I,J) and placing the result at row I, column J.

For example:

```
MAKEMAT(I^2+J^2,3,2)
   [[2,5],[5,8],[10,13]]
```

# 17. Statistics

Press LIB and ▼ to highlight Statistics. Press START, which automatically "presses" NUM, where you see a table with column headings:


The other ApLets (Function, Parametric, Polar, Sequence, and Solve) "press" SYMB when you START, because you likely start by entering formulas or equations, but with Statistics you probably start by entering statistical data, so START goes to the STATISTICS NUMERIC VIEW.

There are 10 dedicated data variables C1, C2, ..., C9, C0. You can think of each one as representing a column of data in a table. The first column shows n, the row numbers for your data columns. You can use the directional arrows ◀ and ▶ to scroll from column to column, and ▲ and ▼ to scroll through the data entries in a specific column.

### *1-Variable vs. 2-Variable Statistics*

There are two "flavors" of statistical work that you can perform with data on the HP 38G.

*1-variable* refers to the types of summary statistics (such as mean, median, standard deviation, etc.) that are commonly used in the description of a single data set (or a set of data values and corresponding frequencies of each value). Such data is often graphically displayed using histograms or box-and-whiskers plots.

*2-variable* refers to the types of statistics (such as correlation and covariance) that are commonly used for *paired* data. Such data is often graphically displayed using a scatterplot, where each pair of values are used as coordinates of a point. In searching for a mathematical model for such data, we often look for a function whose graph best fits these points.

### *NUM Menu*

The type of statistics is chosen using the fifth menu key, which is a toggle that switches back and forth between 1VAR and 2VAR.

When you press NUM, the other menu keys you will see are EDIT, INS, SORT, BIG, and STATS.

EDIT sends the highlighted value to the Editline so you can edit it. OK or ENTER confirms the edited version; CANCL or ON restores the original.

INS lets you insert a new data value at the position occupied by the highlight bar. All other data values in that column will then shift forward.

SORT lets you sort a column's data values in either ascending or descending order. (If the data are paired with those of another column, you can stipulate that the paired entries move in parallel, keeping the pairing intact.)

BIG is a toggle that controls the font size of the data entries.

STATS calculates and displays a variety of statistics in tabular form (the types depending on whether 1VAR or 2VAR is toggled on).

☞ *When* Statistics *is active,* X,T,θ *provides no variable.*

### *Changing, Deleting, and Clearing Data*

To change a data value, simply highlight it and type in the new value. DEL *erases the highlighted data value* (and the data entries below the deleted entry will shift upwards one row); CLEAR *erases an entire column* of data.

☞ *When you press* CLEAR*, the HP 38G will ask you if you really want to clear that column, and offer you* NO *and* YES *keys for you to cancel or verify.*

### *Planetary Data Example*

To explore the various options available with both types of statistics, consider some data on the planets in the solar system. Press NUM and enter:

| n | C1 | C2 | C3 | C4 |
|---|---|---|---|---|
| 1 | .3076 | .4666 | .241 | |
| 2 | .7182 | .7284 | .615 | |
| 3 | .9830 | 1.0170 | 1.000 | |
| 4 | 1.3820 | 1.7654 | 1.881 | |
| 5 | 4.9531 | 5.4525 | 11.862 | |
| 6 | 9.0051 | 10.0735 | 29.458 | |
| 7 | 18.2814 | 20.0846 | 84.013 | |
| 8 | 29.7812 | 30.3342 | 164.794 | |
| 9 | 29.6800 | 49.3576 | 248.430 | |

The row numbers correspond to the planets:

| | |
|---|---|
| 1 | Mercury |
| 2 | Venus |
| 3 | Earth |
| 4 | Mars |
| 5 | Jupiter |
| 6 | Saturn |
| 7 | Neptune |
| 8 | Uranus |
| 9 | Pluto |

In the first column, C1, is each planet's *perihelion distance* (the shortest distance between the planet and the sun during its orbit), measured in *astronomical units* (1 au = the Earth's mean distance from the sun). In the second column, C2, is each planet's *aphelion distance* (the farthest distance between planet and sun during orbit), also measured in astronomical units. And in the third column, C3, is each planet's period of revolution (time for one complete orbit), measured in Earth years.

### *Retrieving Data and Creating New Data*

The columns of data, C1, C2, C3, etc., behave like lists for the purposes of computation on the HOME screen. For example, if you press [HOME] and type [A...Z][C][1][ENTER] you will see all nine perihelion distances displayed as a list.

To retrieve a particular entry in a data column, just type in the row number in parentheses after the name of the column. For example, typing [A...Z][C][3][(][5][)][ENTER] retrieves Jupiter's period of revolution, 11.862 earth years.

This list capability gives you a great way to generate new data columns from existing data. For example, the *mean distance* of a planet from sun is just the average of its perihelion and aphelion distances. Now, you could compute (or look up) each of the nine averages and enter them in a fourth column, C4, but there is a much easier way. On the HOME screen, simply type

[(][C][1][+][C][2][)][/][2][STO▶][A...Z][C][4][ENTER]

This computes the entire list of averages and stores them in tabular form. Press [NUM] now and use the directional arrows to see the data displayed:

| C4 |
|---|
| .3871 |
| .7233 |
| 1 |
| 1.5737 |
| 5.2028 |
| 9.5393 |
| 19.183 |
| 30.0577 |
| 39.5188 |

Notice that whenever a data entry is highlighted, it is also displayed on the Editline.

### *Calculating 1-Variable Statistics*

Under [NUM] you select the "flavor" of statistics you want to investigate. Be sure that **1VAR** is showing, so that the 1-variable statistics are activated.

Press [SYMB] to select the columns of data you wish to investigate. There are five slots, H1, H2, ...H5 for entering and selecting columns of data for statistical calculation or graphical display. (Scroll down with ▼ to see H5.) The menu under [SYMB] is **EDIT** **☑CHK** **C** **SHOW** **EVAL**. The **C** key is simply for typing convenience, and the **☑CHK** is for selecting.

To begin, enter C1, C2, C3, C4 in the slots for H1, H2, H3, H4, respectively. Each will be checked automatically.

```
√H1:  C1    1
√H2:  C2    1
√H3:  C3    1
√H4:  C4    1
```

The 1 by each slot represents the default frequency count for that column. In other words, each entry in each column has an assumed frequency of 1.

For summary statistics for each column of data, return to [NUM] and press **STATS**. A table shows a set of 1-VAR statistics for each selected column.

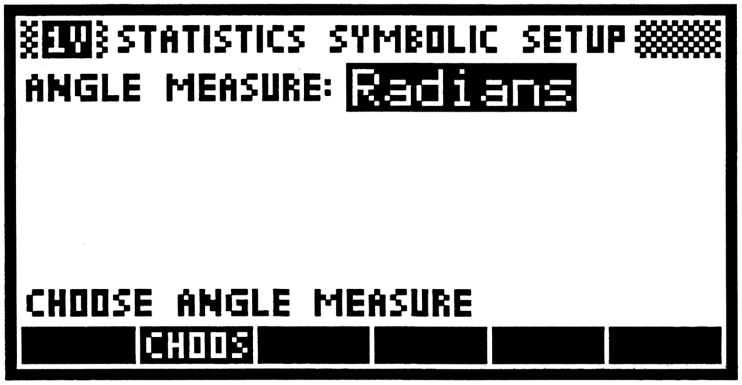
| Statistic | Description |
|---|---|
| NΣ | Number of Data Points |
| TOTΣ | Total (sum of data) |
| MEANΣ | Mean (arithmetic average of data) |
| PVARΣ | Population Variance |
| SVARΣ | Sample Variance |
| PSDEV | Pop. Standard Deviation |
| SSDEV | Sample Std Deviation |
| MINΣ | Minimum (smallest data value) |
| Q1 | 1st Quartile (25% of data at or below this value) |
| MEDIAN | Median (50% of data at or below this value) |
| Q3 | 3rd Quartile (75% of data at or below this value) |
| MAXΣ | Maximum (largest data value) |

Use the directional arrows to scroll around this table of statistics. When the name of a statistic is highlighted in the first column of the table, its description is displayed on the Editline. When the value of a statistic is highlighted for one of the columns H1...H4, its value appears in full machine precision on the Editline. (When you finish examining the statistics, press OK.)

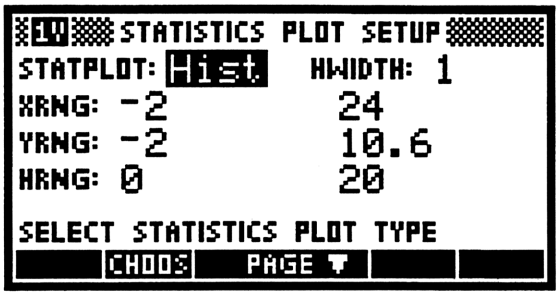
Sometimes one column of data may represent the frequency counts for another column. For example, column C5 could represent blood types in a population (0 = type O, 1 = type A, 2 = type B, 3 = type AB); and column C6 the number of people with each type (100000, 35000, 25000, 5000, respectively). You could denote this under SYMB simply by H5: C5 C6

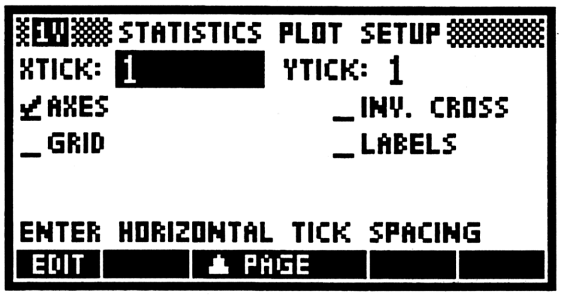
### *Guide to the 1-Variable STATISTICS SETUP Screens*

There is no STATISTICS NUMERIC SETUP; pressing ■NUM does nothing. The other setup screens depend on whether you have 1VAR or 2VAR toggled on under NUM (a small 1V or 2V will show in the upper left corner of the title bar of the setup screens to remind you). With 1VAR active ■SYMB brings you to 1V STATISTICS SYMBOLIC SETUP, where you set the angle measure mode (if relevant):




■PLOT brings you to STATISTICS PLOT SETUP, where you can set the dimensions of the *viewing window* for graphing and the modes that control how graphs are displayed. There are two pages of settings here; you can move between them with the PAGE▼ and ▲PAGE keys.




First on the 1V STATISTICS PLOT SETUP are window settings:

STATPLOT: choice of plot HIST or BOXWHISKER
XRNG: XMIN and XMAX (left and right edges of the viewing window)
YRNG: YMIN and YMAX (lower and upper edges of the viewing window)
HWIDTH: the width (interval size) each frequency bar represents
HRNG: the range of values for which frequency bars will be plotted

To change a highlighted setting, either type in the value you want or press EDIT and edit the current setting. When a choice of options is available, a CHOOS key offers a menu box of available choices. Use ▲ and ▼ to select the option you want. In all cases, use OK or ENTER to make the change; CANCL or ON to cancel. DEL resets the setting to a default value. The default values for all settings are shown in the screen above.

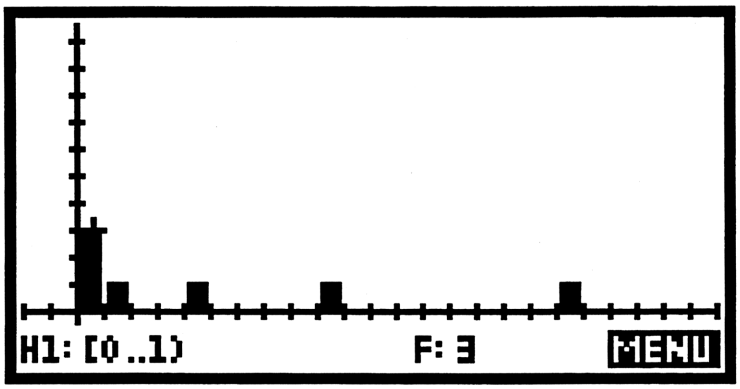
The second page of the 1V STATISTICS PLOT SETUP has "check blanks" for your graphing modes and settings for the tick marks on the axes:

XTICK: the spacing of the marks on the $x$-axis
YTICK: the spacing of the marks on the $y$-axis
AXES check to show the $x$-axis and $y$-axis
INV. CROSS check for inverted "crosshairs" (show white on dark)
LABELS check to have axes labeled with their ranges
GRID check to have lattice points plotted (points that line up with the tick marks on both axes)

CHK toggles these settings (the default settings are shown above).

### *Plotting Histograms*

Only one histogram can be plotted at a time. As an example, suppose we want to see a histogram of the planets' perihelion distances. First, go to SYMB and CHK only ✓H1: C1. Next, press ● PLOT to set up the screen for plotting. Then press CLEAR to reset all the plot settings to their default values (including STATPLOT:, showing Hist for histogram). Now, set the HRNG: from 0 to 30, and press PLOT to see the histogram.




The directional arrows ◀ and ▶ will now move you from one histogram interval to another, showing you the frequency of data points in each. For example, the first histogram interval shown is H1: [0..1] (since HWIDTH was set at the default of 1), with a frequency F: 3. This means that 3 planets have a perihelion distance less than 1 (Mercury, Venus, and Earth).

As you use ▶ to "trace," you see the frequency of data points in each interval (several have a frequency F: 0). The screen will automatically scroll to the right to reach those histogram bars not in view in the original window.

Note that if you press MENU you get the usual plot menu options:

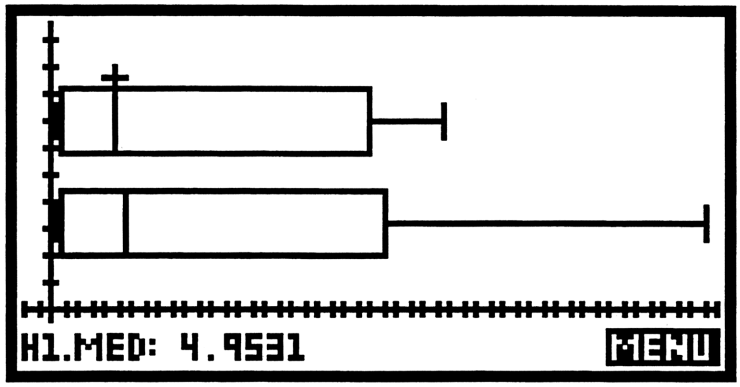
ZOOM TRACE CHAN DEFN

Press MENU again to remove all the menu key labels (pressing any menu key will restore those menu labels and CHAN will redisplay the intervals and frequencies).

### *Box-and-Whiskers Plots*

A popular way to visually display the range of a data set with its median and quartiles is the "box-and-whiskers" plot. Unlike histograms, you can plot more than one (up to five) of these at once on the HP 38G.

For example, suppose you want to examine a box-and-whiskers plot of both the perihelion and aphelion distances of the planets. First, press SYMB and check both H1: C1 and H2: C2. Next, press ■ PLOT to set up the screen for plotting. Use CLEAR to reset all the plot settings to their default values, then set XRNG to [2,50] and CHOOS BoxWhiskers for STATPLOT: (so that BoxW shows). Press PLOT to see the plots.




The end of the left "whisker" marks the minimum of the data points.

The left edge of the box indicates the first quartile.

The line segment inside the box indicates the median.

The right edge of the box indicates the third quartile.

The end of the right "whisker" marks the maximum of the data points.

◀ and ▶ will now trace from quartile to quartile on a single box-and-whiskers, showing the value at the bottom of the screen. With more than one box-and-whiskers, ▲ and ▼ will switch you from one to another. The screen will scroll to reach quartiles not in view in the original viewing window.

### *Calculating 2-Variable Statistics*

Go to [NUM] to toggle 1VAR to 2VAR, to activate *2-variable* statistics. Press [SYMB] to select the *pairs* of data columnsyou wish to investigate. There are five sets, S1, S2, S3, S4, and S5, for entering and selecting pairs of columns for statistical calculation or graphical display. With each set you can also choose a model to fit to the data (use ▼ to see all five sets).

The menu in [SYMB] is EDIT ☑CHK CAT SHOW EVAL. The CAT is a typing aid; ☑CHK is for selecting. Press [CLEAR] to reset the choices and then, for the data set S1, enter CAT [3] (planets' periods of revolution) and CAT [4] (planets' mean distances from the sun):

```
√S1:  C3    C4
√Fit1:  m*X+b
 S2:
 Fit2:  m*X+b
```

To calculate a variety of relevant statistics for this pair of data columns, return to [NUM] and press STAT. A table shows a column of 2-VAR statistics:

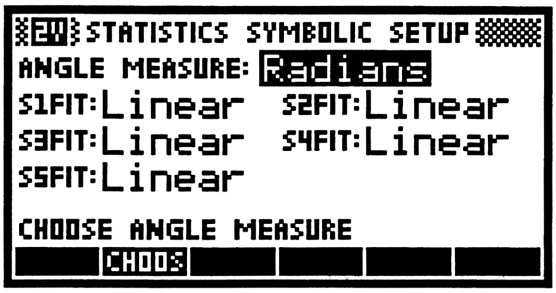
| Statistic | Description | |
|---|---|---|
| MEANX | Mean of X | (average of data in first column) |
| ΣX | Sum of X | (sum of data in first column) |
| ΣX^2 | Sum of X^2 | (sum of squares in first column) |
| MEANY | Mean of Y | (average of data in second column) |
| ΣY | Sum of Y | (sum of data in second column) |
| ΣY^2 | Sum of Y^2 | (sum of squares in second column) |
| ΣXY | Sum of X*Y | (sum of products) |
| CORR | Correlation | |
| COV | Covariance | |

Use the directional arrows to scroll through the table of statistics. When the statistic name is highlighted in the first column, its description appears on the Editline. When any table value is highlighted, its full precision appears on the Editline. When you finish examining the statistics, press OK.

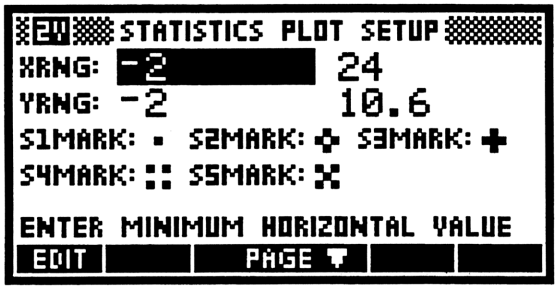
### *Guide to the 2-Variable STATISTICS SETUP Screens*

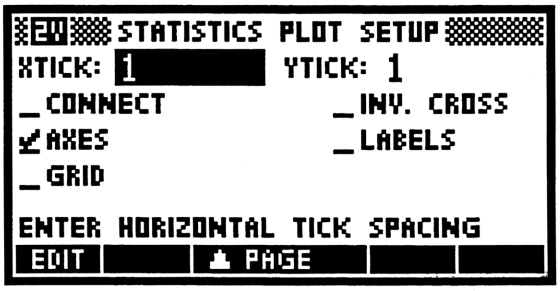
There is no STATISTICS NUMERIC SETUP; pressing ■NUM does nothing. The other setup screens depend on whether you have 1VAR or 2VAR toggled on in NUM (a small 1V or 2V will show in the upper left corner of the title bar to remind you ).

With 2VAR active, ■SYMB displays 2V STATISTICS SYMBOLIC SETUP, where you set the angle measure mode (if relevant). You can also CHOOS the type of regression fit for any of the five paired sets of data, S1, S2, S3, S4, or S5:




■PLOT brings you to STATISTICS PLOT SETUP, where you can set the dimensions of the *viewing window* for graphing, and set the modes that control how graphs are displayed. There are two pages of settings here; you move between them with the PAGE▼ and ▲PAGE keys.



On the first page of the 2V STATISTICS PLOT SETUP are your window settings and the selections for the type of marks you can choose for the points shown in a scatter plots.

| | |
|---|---|
| XRNG: | XMIN and XMAX (left and right edges of the viewing window) |
| YRNG: | YMIN and YMAX (lower and upper edges of the viewing window) |
| S1MARK: | how a point for data set S1 is displayed |
| S2MARK: | how a point for data set S2 is displayed |
| S3MARK: | how a point for data set S3 is displayed |
| S4MARK: | how a point for data set S4 is displayed |
| S5MARK: | how a point for data set S5 is displayed |

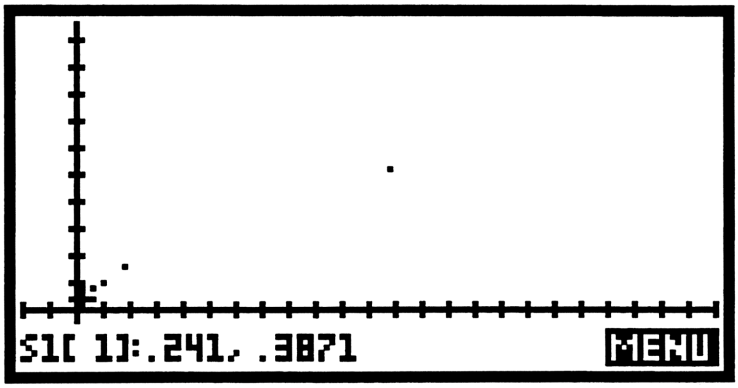
To change a highlighted setting, either type in the value you want or press EDIT and edit the current setting. When a choice of options is available, a CHOOS key gives you a menu box of available choices. Use ▲ and ▼ to select the option you want. In all cases, you press OK or ENTER to make the change, or CANCL or ON if you change your mind. If you press DEL the setting is automatically changed to a default value. Default values for all settings are shown in the screens on the previous page.

The second page of the 2V STATISTICS PLOT SETUP has "blanks" to CHK your desired graphing modes and settings for the axis tick marks:

| | |
|---|---|
| XTICK: | the spacing of the marks on the $x$-axis |
| YTICK: | the spacing of the marks on the $y$-axis |
| CONNECT | check for connected graphing or don't for "dot" mode |
| AXES | check to show the $x$-axis and $y$-axis |
| INV. CROSS | check for inverted "crosshairs" (show white on dark) |
| LABELS | check to have axes labeled with their ranges |
| GRID | check to have lattice points plotted (points that line up with the tick marks on both axes) |

## *Scatterplots*

A *scatterplot* of points (coordinate pairs) is a useful way to display paired data. For example, suppose you want to see the planets' mean distances from the sun plotted against their periods of revolution. Each scatterplot point (one for each planet), would have its first coordinate (independent variable) represent the period of revolution and the second coordinate (dependent variable) represent the mean distance to the sun. First, go to SYMB and see that this is exactly what you have for S1: √S1: C3 C4
Now, press ■ PLOT to set up the screen for plotting. Press CLEAR te reset all the plot settings to their default values. Press PLOT to see the scatterplot.




Now ◀ and ▶ will move you from one point to another, showing you both the label of the point (S1[1], S1[2], ..., S1[9] for the nine planets) and the coordinates. As you use ▶ to trace the points, the screen will scroll both to the right and up to reach points not in view in the original viewing window.

MENU offers the usual plot menu options: ZOOM TRACE (X,Y) DEFN. Press MENU again to remove all the menu key labels (any menu key will restore the menu labels and (X,Y) redisplays coordinates of the points).

If you select more than one pair of columns for scatterplots, then you need a way to distinguish the points belonging to the different scatterplots. You have a choice of five different marks (for five possible scatterplots) by using CHOOS for S1MARK, S2MARK, ..., S5MARK in the 2V STATISTICS PLOT SETUP (■ PLOT). When you have more than one scatterplot, ▲ and ▼ allow you to switch from one data set to another while tracing.

### *Fitting Equations to Data*

A model for paired data $(x,y)$ is a function $y = f(x)$. The "fit" of the model is measured by how well the graph of $y = f(x)$ fits the plotted data points. A regression function is a function of a certain type that is chosen on a "least squares" criterion. For example, a regression line is a linear function $f(x)$ chosen so that the sum of the squared differences $(y\text{-}f(x))^2$ is as small as possible for all the data points $(x,y)$.

You can choose from among several different standard regression models for paired data (or make one up of your own). To select a model for the planetary data (where X is the period of revolution in data column C3 and Y is the mean distance from the sun in data column C4), press ■ SYMB to go to the 2V STATISTICS SYMBOLIC SETUP. Highlight SIFIT and press CHOOS to see the choices possible:

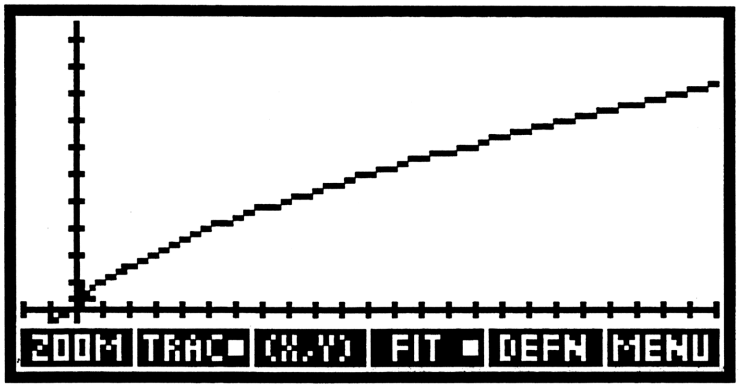
| Type | Formula $f(x)$ |
|---|---|
| Linear | m*X+b |
| Logarithmic | m*LN(X)+b |
| Exponential | b*EXP(m*X) |
| Power | b*X^m |
| Quadratic | a*X^2+b*X+c |
| Cubic | a*X^3+b*X^2+c*X+d |
| Logistic | L/(1+a*EXP(-b*X)) |
| User Defined | f(X) |

Highlight the fit of your choice and then press **OK**.

For example, **CHOOS** Power for S1FIT and press **OK**. Then return to SYMB to see

```
√S1:   C3     C4
√Fit1:  b*X^m
```

Now press PLOT to see the scatterplot once again. Press **FIT** to see the regression power function of best least-squares fit.




Press **DEFN** to see the equation of the function (though it won't fit on screen). For a better look, return to SYMB and highlight Fit1, then press **EDIT** and you can scroll through the whole formula.

To enter a function of your own choosing, simply go to SYMB, highlight Fit1 and type an expression of your choice. (Try this with X^(2/3) and compare that fit to the power function the HP 38G found for you. Kepler originally came up with this choice!)

# 18. Guide to the VAR Menu

All variables are found under the [VAR] menu. When you press [VAR] you'll see a two-column menu. The left column shows the types of HOME variables.

| TYPE | DESCRIPTION |
|---|---|
| Complex | Complex variables Z1, Z2, ..., Z0 |
| Graphic | Graphics variables G1, G2, ..., G0 |
| Library | ApLets Function, Parametric, Polar, Sequence, Solve, Statistics, and any other user-saved ApLets |
| List | List variables L1, L2, ..., L0 |
| Matrix | Matrix *and* Vector variables M1, M2, ..., M0 |
| Modes | MODES settings Ans, Date, HAngle, HDigits, HFormat, Ierr, Time |
| Notepad | Notes (named as you choose) |
| Program | Programs (named as you choose). Note that the Edit line is considered to be a program. |
| Real | Real variables A, B, C, ..., X, Y, Z, θ |

### *Navigating the VAR menu*

Use ▲ and ▼ to scroll to the variable type of your choice. As you move from type to type, the right-hand column changes to show you those variables. For example, if you scroll down to the List category, the right-hand menu should show the menu of list variables L1, L2, ..., L0. As with all HP 38G scroll-down menus, if you scroll past the last item, you return to the first item.

After highlighting the variable type you want, press ▶ (or OK or [ENTER]) to move to the right-hand column (the category on the left will now have a box around it). Now you can scroll through this menu for the specific variable that you want. Highlight the desired variable and press OK or [ENTER]. To return to the left-hand column of the [VAR] menu, press ◀. If you change your mind and simply want to leave the [VAR] menu, press CANCEL or [ON].

### *Retrieving by NAME or VALUE*

When using the VAR menu to retrieve a variable, you can retrieve its *name* or its *value*. For example, go HOME and type 3 STO▶ A...Z A. Press VAR and see that NAM☐ is toggled on (the ☐ replaces the E in NAME). Select the category Real and press OK. Now with A highlighted, press OK again—the variable *name*, A is echoed to the Editline. Repeat the process with VALU☐ toggled on this time...now you get A's *value*, 3 on the Editline.

### *Default Values of HOME Variables*

The variables reserved for real numbers, complex numbers, graphics, lists, and matrices always have a default value if you do not store a value yourself.

| VARIABLE | DEFAULT VALUE |
|---|---|
| Complex variables Z1, Z2, ..., Z0 | (0,0) |
| Graphics variables G1, G2, ..., G0 | a blank screen |
| List variables L1, L2, ..., L0 | { } (an empty list) |
| Matrix variables M1, M2, ..., M0 | [[0]] (a 1x1 zero matrix) |
| Real variables A, B, C, ..., X, Y, Z, θ | 0 |

Many of the Modes default to a value corresponding to a particular setting:

| MODE | POSSIBLE VALUES | DEFAULT VALUE |
|---|---|---|
| Ans | last computed result from HOME screen | 0 |
| HAngle | 1 Degrees 2 Radians 3 Grads | 1 |
| HDigits | 0-11 digits after decimal mark (in Fixed, Scientific, or Engineering) | 0 |
| HFormat | 0 Standard 1 Fixed 2 Scientific 3 Engineering 4 Fraction | 0 |
| Ierr | 0-11 digits of precision for definite integrals | 0 |

### *Some Navigational Shortcuts for Menus*

If you know the first letter of the category you want, just press the key with that letter to go to that section of the menu (i.e. it's not necessary to press A...Z first). For example, if you are in the left-hand menu and you press R (the multiplication key), this selects the Real category.

In the case of more than one category starting with the same letter, the letter key always takes you to the *next* category beginning with that letter. For example, if you are at the top of the menu of categories (with Complex highlighted) and you press L once, you go immediately to Library. Press L again and you go to List. The same shortcut applies when you are in a particular menu from the right-hand column.

You also may find it useful to know that ▲ or ▼ always takes you to the top or the bottom of a menu, respectively. And when you are in the right-hand menu, the ▶ will advance you, one "page" (four entries) at a time, through the menu until you reach the end.

### *ApLet Variables*

Each of the ApLets (Function, Parametric, Polar, Sequence, Solve, and Statistics) has its own set of variables associated with it. To get the menu of variables associated with the current ApLet, press APLET on the VAR screen. This brings up a new double-menu of the variables for that ApLet.

| CATEGORY | DESCRIPTION |
|---|---|
| Plot | Variables associated with the PLOT settings |
| Symbolic | Equations associated with the SYMB settings |
| Numeric | Variables associated with the NUM settings |
| Note | The variable called NoteText found under NOTE |
| Sketch | Two variables called PageNum and Page found under SKETCH |

On the next two pages are a listing of all the variables that can be found in each category of each ApLet.

## *Plot Variables for ApLets*

| Function | Parametric | Polar | Sequence | Solve | Statistics |
|---|---|---|---|---|---|
| Axes | Axes | Axes | Axes | Axes | Axes |
| Connect | Connect | Connect | Connect | Connect | Connect |
| Coord | Coord | Coord | Coord | Coord | Coord |
| FastRes | FastRes | FastRes | FastRes | FastRes | FastRes |
| Grid | Grid | Grid | Grid | Grid | Grid |
| Indep | Indep | Indep | Indep | Indep | Indep |
| InvCross | InvCross | InvCross | InvCross | InvCross | InvCross |
| Labels | Labels | Labels | Labels | Labels | Labels |
| Recenter | Recenter | Recenter | Recenter | Recenter | Recenter |
| Simult | Simult | Simult | Simult | Simult | Simult |
| Tracing | Tracing | Tracing | Tracing | Tracing | Tracing |
| Xcross | Xcross | Xcross | Xcross | Xcross | Xcross |
| Ycross | Ycross | Ycross | Ycross | Ycross | Ycross |
| Xtick | Xtick | Xtick | Xtick | Xtick | Xtick |
| Ytick | Ytick | Ytick | Ytick | Ytick | Ytick |
| Xmin | Xmin | Xmin | Xmin | Xmin | Xmin |
| Xmax | Xmax | Xmax | Xmax | Xmax | Xmax |
| Ymin | Ymin | Ymin | Ymin | Ymin | Ymin |
| Ymax | Ymax | Ymax | Ymax | Ymax | Ymax |
| Xzoom | Xzoom | Xzoom | Xzoom | Xzoom | Xzoom |
| Yzoom | Yzoom | Yzoom | Yzoom | Yzoom | Yzoom |
| | Tmin | θmin | Nmin | | Hmin |
| | Tmax | θmax | Nmax | | Hmax |
| | Tstep | θstep | | | Hwidth |
| Plot FCN | | | SeqPlot | | StatPlot |
| Area | | | | | S1Mark |
| Extremum | | | | | S2Mark |
| Isect | | | | | S3Mark |
| Root | | | | | S4Mark |
| Slope | | | | | S5Mark |

### *Symbolic Variables for ApLets*

| Function | Parametric | | Polar | Sequence | Solve | Statistics |
|---|---|---|---|---|---|---|
| Angle | Angle | | Angle | Angle | Angle | Angle |
| F1 | X1 | Y1 | R1 | U1 | E1 | Sfit1 |
| F2 | X2 | Y2 | R2 | U2 | E2 | Sfit2 |
| F1 | X3 | Y3 | R3 | U3 | E3 | Sfit3 |
| F4 | X4 | Y4 | R4 | U4 | E4 | Sfit4 |
| F5 | X5 | Y5 | R5 | U5 | E5 | Sfit5 |
| F6 | X6 | Y6 | R6 | U6 | E6 | |
| F7 | X7 | Y7 | R7 | U7 | E7 | |
| F8 | X8 | Y8 | R8 | U8 | E8 | |
| F9 | X9 | Y9 | R9 | U9 | E9 | |
| F0 | X0 | Y0 | R0 | U0 | E0 | |

### *Numeric Variables for ApLets*

| Function | Parametric | Polar | Sequence | Solve | Statistics | |
|---|---|---|---|---|---|---|
| Digits | Digits | Digits | Digits | Digits | C1 | Digits |
| Format | Format | Format | Format | Format | C2 | Format |
| NumCol | NumCol | NumCol | NumCol | NumCol | C3 | NumCol |
| NumFont | NumFont | NumFont | NumFont | | C4 | NumFont |
| NumIndep | NumIndep | NumIndep | NumIndep | | C5 | |
| NumRow | NumRow | NumRow | NumRow | NumRow | C6 | NumRow |
| NumStart | NumStart | NumStart | NumStart | | C7 | StatMode |
| NumStep | NumStep | NumStep | NumStep | | C8 | |
| NumType | NumType | NumType | NumType | | C9 | |
| NumZoom | NumZoom | NumZoom | NumZoom | | C0 | |

### *Note Variables for ApLets*

| Function | Parametric | Polar | Sequence | Solve | Statistics |
|---|---|---|---|---|---|
| NoteText | NoteText | NoteText | NoteText | NoteText | NoteText |

### *Sketch Variables for ApLets*

| Function | Parametric | Polar | Sequence | Solve | Statistics |
|---|---|---|---|---|---|
| PageNum | PageNum | PageNum | PageNum | PageNum | PageNum |
| Page | Page | Page | Page | Page | Page |

# 19. Guide to the MATH Menu

All math functions not on the keyboard are under the [MATH] menu. When you press [MATH] you'll see a two-column menu overlaid on your calculator screen. The left column contains the categories of MATH FUNCTIONS.

### *Categories of Math Functions*

| CATEGORY | DESCRIPTION |
|---|---|
| Calculus | Tools for derivatives, integrals, and Taylor polynomials |
| Complex | Tools for working with complex numbers |
| Constant | Special constants (like $e$ and $i$) |
| Hyperb. | Hyperbolic and inverse hyperbolic functions |
| List | Tools for working with lists |
| Loop | Tools for iteration, recursion, and summation |
| Matrix | Tools for working with both vectors and matrices |
| Polynom. | Tools for working with polynomials |
| Prob. | Tools for probability (like combinations and permutations) |
| Real | Tools for real numbers |
| Stat-Two | Tools for predictions with paired data |
| Symbolic | Tools for working algebraically with expressions |
| Tests | Logical operators and relations (like $<$, $\leq$, $>$, $\geq$) |
| Trig. | Other trigonometric and inverse trigonometric functions |

### *Programming Commands and Constants*

Press the CMDS key in [MATH] to activate the double menu for PROGRAM COMMANDS. Press the CONS key in [MATH] to activate the double menu for PROGRAM CONSTANTS. Programming is not discussed here. Refer to your HP 38G owner's manual or to *A Guide to the HP 38G MATH Menu and Programming* for a discussion of programming.

### *Navigating the* [MATH] *Menu*

Use ▲ and ▼ to scroll to the category of your choice. As you move, the right-hand column will change to show you the contents of each category. For example, if you scroll down to the Hyperb. category, the right-hand menu shows the hyperbolic and inverse hyperbolic functions. As with all HP 38G scroll-down menus, if you scroll past the last item, you return to the first item.

After highlighting the category you want, press ▶ (or OK or [ENTER]) to move to the right-hand column. (The category selected in the left-hand column is now in a box.) Now you can scroll through the menu for this category to get the item you want. When you have highlighted the desired item, just press OK or [ENTER]. To get back to the left-hand column level of the [MATH] menu, press ◀ again. If you change your mind and simply want to leave the [MATH] menu, press CANC or [ON].

### *Some Navigational Shortcuts for Menus*

The categories are arranged alphabetically, as is the menu for each category (for the most part). If you know the first letter of the category you want, just press the key with that letter to go that section of the menu. (It's not necessary to press [A...Z] first, but it won't hurt anything.) For example, if you are in the left-hand menu for MATH FUNCTIONS and you press [M] (the [9] key), this selects the Matrix category.

If more than one category starts with the same letter, a letter key always takes you to the *next* category beginning with that letter. For example, if you press [P] once, you go immediately to Polynom. Press [P] again and you go to Prob. The same shortcut applies when you are in a particular menu from the right-hand column.

Also, note that ▶▲ or ▶▼ takes you to the top or the bottom of a menu, respectively. And when you are in the right-hand menu, the ▶ will advance you one "page" (four entries) at once through the menu.

## *Directory of MATH Functions*

This section is a directory of all the math functions found in [MATH]. See also Sections 14, 15, and 16 for working examples (and for a comprehensive description of all these functions and their syntax, please refer to your HP 38G owner's manual).

| CATEGORY | CONTENTS | | | |
|---|---|---|---|---|
| Calculus | ∂ | ∫ | TAYLOR | |
| Complex | ARG | CONJ | IM | RE |
| Constant | e (= 2.71828182846) | | i (= (0,1)) | |
| | MAXREAL (= 9.99999999999E499) | | MINREAL (= 1.E-499) | |
| | π (= 3.14159265359) | | | |
| Hyperb. | ACOSH | ASINH | ATANH | |
| | COSH | SINH | TANH | |
| | ALOG | EXP | EXPM1 | LNP1 |
| List | CONCAT | ΔLIST | MAKELIST | πLIST |
| | POS | REVERSE | SIZE | ΣLIST |
| | SORT | | | |
| Loop | ITERATE | RECURSE | Σ | |

| | | | | |
|---|---|---|---|---|
| Matrix | COLNORM | COND | CROSS | DET |
| | DOT | EIGENVAL | EIGENVV | IDENMAT |
| | INVERSE | LQ | LSQ | LU |
| | MAKEMAT | QR | RANK | ROWNORM |
| | RREF | SCHUR | SIZE | SPECNORM |
| | SPECRAD | SVD | SVL | TRACE |
| | TRN | | | |
| Polynom. | POLYCOEF | POLYEVAL | POLYFORM | POLYROOT |
| Prob. | COMB | ! | PERM | RANDOM |
| | UTPC | UTPF | UTPN | UTPT |
| Real | CEILING | DEG→RAD | FLOOR | FNROOT |
| | FRAC | HMS→ | →HMS | INT |
| | MANT | MAX | MIN | MOD |
| | % | % CHANGE | % TOTAL | RAD→DEG |
| | ROUND | SIGN | TRUNC | XPON |
| Stat-Two | PREDX | PREDY | | |
| Symbolic | = | ISOLATE | LINEAR? | QUAD |
| | QUOTE | \| | | |
| Tests | < | ≤ | == | ≠ |
| | > | ≥ | AND | IFTE |
| | NOT | OR | XOR | |
| Trig. | ACOT | ACSC | ASEC | |
| | COT | CSC | SEC | |

# 20. Making Notes and Sketches

You can create notes of text or sketch pictures on the HP 38G.

### *The* NOTEPAD

If you press NOTEPAD (■ 1) you will see a screen with the title bar NOTE CATALOG. To create a new *note*, press NEW. At the prompt, type the name of your choice, then OK or ENTER (or CANCL or ON if you change your mind). For example, type in (A...Z) H E L L O as the name of your note and press OK. The title bar will change to show HELLO NOTE. Now you can type in whatever text you wish. Notice the extra menu keys that are provided for typing convenience.

### *Note Editor*

A...Z on the menu is an "alpha lock" key that can be toggled on or off. (A small white square lights up on the menu label when it is activated.) When the alpha is locked on, the regular A...Z key can be used to temporarily turn it *off* (if you need to type a number, for example). As soon as you press any key, the α will come back on automatically. (Press ■ A...Z to lock lowercase letters.) SPACE and BKSP (backspace) are also here for typing convenience. ENTER serves as a "carriage return" and will bring you to a new line.

### *Example Using the CHARS Menu*

CHARS gives you access to additional special characters, mathematics symbols, Greek letters, punctuation, and diacritical marks. With A...Z off, press CHARS. Move to the ¿ on the first row with the directional arrow ▶ and press OK when it is highlighted. This "echoes" the symbol back to your note exactly where your cursor was flashing. (To retrieve several symbols in a row from CHARS, use ECHO instead of OK for each character. Then

press OK after echoing the last character you want.) Now lock alpha by pressing A...Z (the white square should appear), and type:

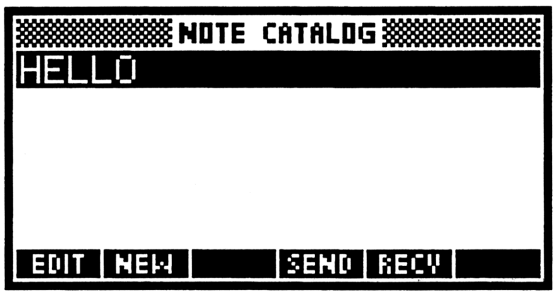
| | |
|---|---|
| C O M O SPACE E S T | (hold ■ down for lower case letters) |
| A...Z | (to turn off the alpha lock) |
| ■ CHARS | (to return to CHARS) |
| PAGE▼ PAGE▼ | (to go to the third page of CHARS) |
| ▼ ▼ ▶ OK | (to retrieve the á) |
| A...Z | (to turn alpha lock back on) |
| U S T E D | (hold ■ down for lower case) |
| A...Z ■ CHARS | (to unlock alpha and return to CHARS) |
| (select:) ? OK | (retrieve the question mark) |

You should see the following on your screen:


ENTER serves as a carriage return.

You are not limited to a single screen of text. You can type in as much as you want. When one "page" is full, the screen will automatically scroll and the ▲PAGE will show you that more text is above the current line. For example, press ENTER repeatedly until your line of Spanish text disappears. Now type the translation, How are you?, so that the screen looks like this:

You can have as many pages of text as you want in a single note (up to what the memory of your HP 38G will allow); the menu label will appear as PAGE ▼, ▲ PAGE, or ▲ PAGE ▼, depending if you are on the first page, last page, or some page in between. Press NOTEPAD and you will see that HELLO now resides in your NOTE CATALOG:




### *Editing a Note*

To edit a note, highlight its name in the NOTE CATALOG and press EDIT. You can use the directional arrow keys ▲, ▼, ▶, and ◀ to move around the note. You can insert additional text wherever the flashing cursor is located. DEL will erase the character that the cursor is flashing on top of. CLEAR will erase the entire note (you will be prompted to verify that you really want to do this and given YES and NO menu keys to respond with).

### *Deleting and Clearing Notes*

To delete a saved note, highlight its name in the NOTE CATALOG and press DEL. To delete *all* the saved notes, press CLEAR.

### *Sending and Receiving Notes*

SEND lets you send a highlighted note to another HP 38G or to a Disk Drive. RECV lets you receive a highlighted note from another HP 38G or from a Disk Drive.

## NOTE *View*

Every ApLet has PLOT, SYMB, and NUM views. In addition, you can include a NOTE or SKETCH with an ApLet (either one of the built-in ApLets or one that you save). To make a note, press NOTE (■ VAR). At the top of the screen you will see the name of the current ApLet, followed by NOTE. Here you can type a note exactly as you would in the NOTEPAD (perhaps some explanation of the equations or data contained in that ApLet). If you save the ApLet with a name of your choosing, then this note remains "attached." To attach a note already saved in the NOTEPAD to a current ApLet, do this:

1. Press NOTE for the current ApLet.
2. Press VAR to bring up the menu of variables.
3. Toggle on VALUE.
4. Select Notepad, press OK.
5. Select the name of the note you want and press OK.

This should "paste in" the contents of your note.

Similarly, if you would like to save a note that is attached to the current ApLet as a note in your NOTEPAD, then do this:

1. Press NOTEPAD and name a NEW note.
2. Press VAR to bring up the menu of variables.
3. Toggle on APLET to bring up the menu of current ApLet variables.
4. Toggle on VALUE.
5. Select Note, press OK.
6. With NoteText highlighted, press OK.

This should "paste in" the contents of the ApLet NOTE to your new note in NOTEPAD.

## SKETCH *View*

You can also make a picture or diagram for an ApLet. Press SKETCH (i.e. ■MATH) to see a blank screen with a menu, STOP HELP TEXT DRAW. TEXT lets you place a block of text anywhere you wish in your picture. When you press this key the Editline appears along with BIG (a toggle for big or small font size) and A...Z (an alpha lock for typing convenience). Type in your name and press OK. A little box shows up on screen that you can position with your directional arrows. When the box is you want the text to appear, press OK. This lets you put labels wherever you please.

### *Drawing Tools*

DRAW brings up drawing tools. Here's what they do:

When you toggle on DOT+, your crosshairs turns into an "etch-a-sketch" tool, leaving a trail of dark pixels behind as you move it around the screen. When you toggle on DOT−, your crosshairs turns into a pixel "eraser."

> ☞ *Toggle off both DOT+ and DOT− if you simply want to move your crosshairs to a new position.*

Press LINE and then move your crosshairs to a new position. When you press OK you have a line segment drawn between the starting position and the ending position. Press BOX and then move your crosshairs to a new position. When you press OK you have a rectangular box drawn with the starting position and the ending position as opposite corners. Press CIRCL and then move your crosshairs to a new position. When you press OK you have a circle drawn with the starting position at the center and the ending position on the circumference.

For any of these drawing features, there is a CANCL key available if you change your mind in the middle of the process. And NEXP gives you a "new page" if you need more than one screen for your picture.

### *Storing a Graphic*

When you are done with your picture, it will stay in the SKETCH view of the current ApLet. If you save the ApLet under a name of your choosing, the picture stays attached to the saved ApLet. To change the picture in an ApLet, but still save the original, the STO▶ key in SKETCH allows this. Press STO▶ and a menu box comes up with a list of your *graphic variables*, G1, G2, ..., G9, G0. Highlight G1 and press OK. You are prompted to place your crosshairs at one corner of the picture (or wherever you want). Press OK and you are prompted to place the crosshairs at a second (opposite) corner. Press OK and the picture (or the piece you have boxed in) is safely stored away in that graphic variable.

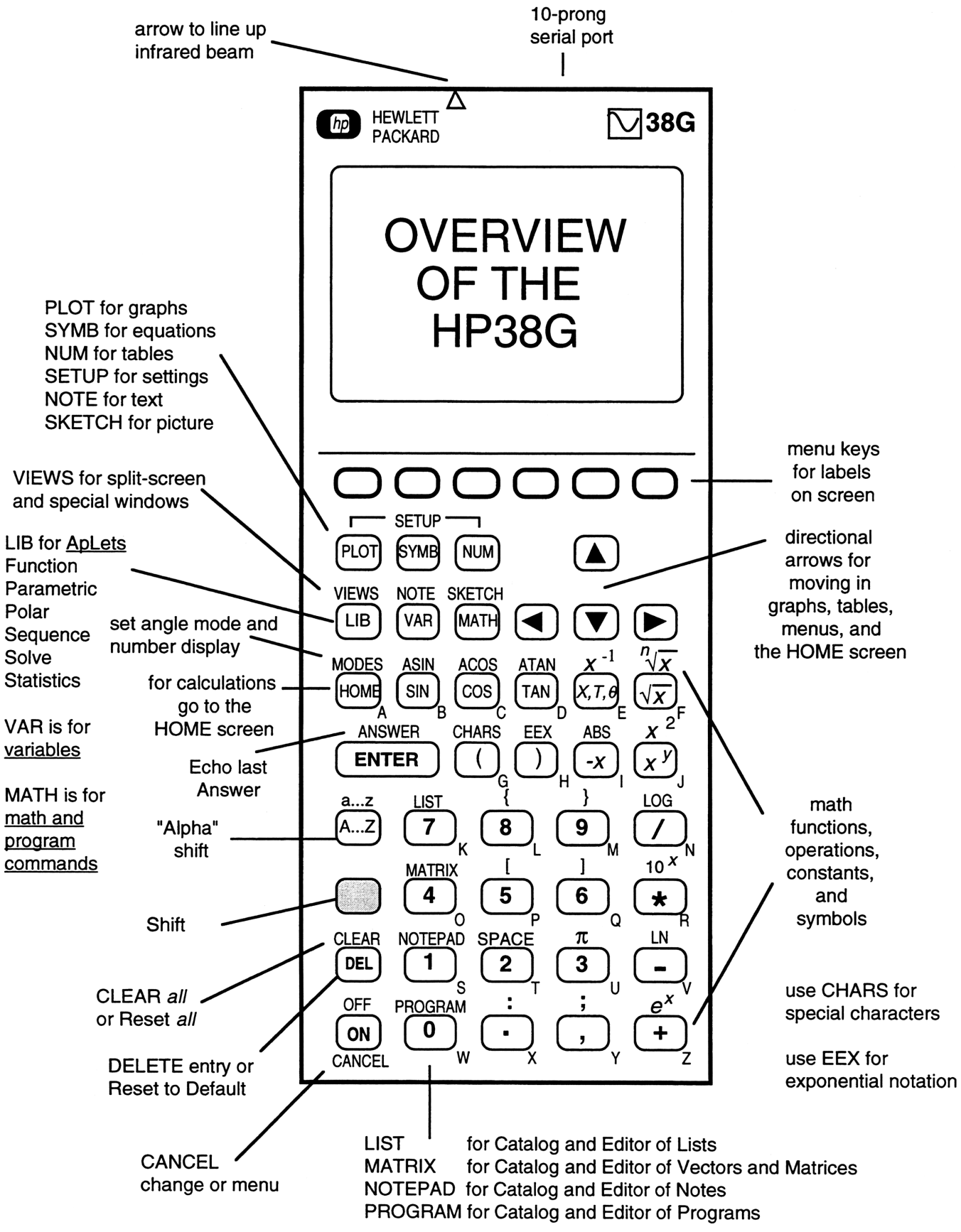
### *Retrieving a Graphic and Saving Screen Captures*

Now suppose you want to retrieve a saved graphic and "paste" it into the SKETCH view of the current ApLet. The procedure is similar to the procedure for pasting notes:

1. Press SKETCH for the current ApLet.
2. Press VAR to bring up the menu of variables.
3. Toggle on VALUE.
4. Select Graphic, press OK.
5. Select the the graphic variable you want (for example: G1) and press OK.

This pastes the contents of the graphic variable into your SKETCH view.

Suppose you have graphed something in PLOT and you would like to save it as a graphic. The HP 38G has a screen capture feature. If you press both ON and PLOT down at the same time, the current screen is automatically stored in G0. Then you can use the procedure outlined above to paste the graphic into SKETCH. Now you can add your own picture elements or text!


arrow to line up infrared beam
10-prong serial port
HEWLETT PACKARD
38G
OVERVIEW OF THE HP38G
PLOT for graphs
SYMB for equations
NUM for tables
SETUP for settings
NOTE for text
SKETCH for picture
VIEWS for split-screen and special windows
LIB for ApLets
Function
Parametric
Polar
Sequence
Solve
Statistics
VAR is for variables
MATH is for math and program commands
set angle mode and number display
for calculations go to the HOME screen
Echo last Answer
"Alpha" shift
Shift
CLEAR all or Reset all
DELETE entry or Reset to Default
CANCEL change or menu
menu keys for labels on screen
directional arrows for moving in graphs, tables, menus, and the HOME screen
math functions, operations, constants, and symbols
use CHARS for special characters
use EEX for exponential notation
LIST for Catalog and Editor of Lists
MATRIX for Catalog and Editor of Vectors and Matrices
NOTEPAD for Catalog and Editor of Notes
PROGRAM for Catalog and Editor of Programs