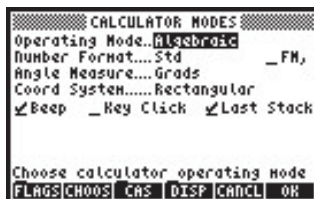# Appendix C
CAS settings

CAS stands for *Computer Algebraic System*. This is the mathematical core of the calculator where the symbolic mathematical operations and functions are programmed. The CAS offers a number of settings can be adjusted according to the type of operation of interest. To see the optional CAS settings use the following:

• Press the $\boxed{\text{MODE}}$ button to activate the CALCULATOR MODES input form.

```
▒▒▒▒▒▒ CALCULATOR MODES ▒▒▒▒▒▒
Operating Mode..Algebraic
Number Format....Std        _FM,
Angle Measure....Grads
Coord System......Rectangular
✓Beep  _Key Click ✓Last Stack


Choose calculator operating mode
FLAGS CHOOS  CAS  DISP CANCL  OK
```

At the bottom of the display you will find the following soft menu key options:

FLAGS	Provides menus for manipulating calculator flags (*)
CHOOS	Lets the user chose options in the different fields in the form
CAS	Provides an input form to change CAS settings
DISP	Provides an input form to change display settings
CANCL	Closes this input form and returns to normal display
OK	Use this key to accept settings

(*) Flags are variables in the calculator, referred to by numbers, which can be "set" and "unset" to change certain calculator operating options.

Pressing the $\boxed{\text{NXT}}$ key shows the remaining options in the CALCULATOR MODES input form:

RESET	Allows the user to reset a highlighted option
CANCL	Closes this input form and returns to normal display
OK	Use this key to accept settings

- To recover the original menu in the CALCULATOR MODES input box, press the `NXT` key. Of interest at this point is the changing of the CAS settings. This is accomplished by pressing the ▆▆▆▆ soft menu key. The default values of the CAS setting are shown below:

```
░░░░░░░░░░░░░ CAS MODES ░░░░░░░░░░░░░
Indep var:s
Modulo:   13
■Numeric _Approx     _Complex
✓Verbose _Step/Step _Incr Pow
✓Rigorous✓Simp Non-Rational


Replace constants by values?
 EDIT       ✓CHK       CANCL  OK
```

- To navigate through the many options in the CAS MODES input form, use the arrow keys: ◁ ▷ ▽ △ .

- To select or deselect any of the settings shown above, select the underline before the option of interest, and toggle the ✓▆▆▆▆ soft menu key until the right setting is achieved. When an option is selected, a check mark will be shown in the underline (e.g., the *Rigorous* and *Simp Non-Rational* options above). Unselected options will show no check mark in the underline preceding the option of interest (e.g., the _*Numeric, _Approx, _Complex, _Verbose, _Step/Step, _Incr Pow* options above).

- After having selected and unselected all the options that you want in the CAS MODES input form, press the ▆▆▆▆ soft menu key. This will take you back to the CALCULATOR MODES input form. To return to normal calculator display at this point, press the ▆▆▆▆ soft menu key once more.

Selecting the independent variable

Many of the functions provided by the CAS use a pre-determined independent variable. By default, such variable is chosen to be the letter *X* (upper case) as shown in the CAS MODES input box above. However, the user can change this variable to any other letter or combination of letters and numbers (a variable name must start with a letter) by editing the *Indep var* field in the CAS MODES input box.

A variable called VX exists in the calculator's {HOME CASDIR} directory that takes, by default, the value of 'X'. This is the name of the preferred independent variable for algebraic and calculus applications. For that reason, most examples in this Chapter use X as the unknown variable. If you use other independent variable names, for example, with function HORNER, the CAS will not work properly.

The variable VX is a permanent inhabitant of the {HOME CASDIR} directory. There are other CAS variables in the {HOME CASDIR}, e.g., REALASSUME (▨▨▨▨▨), MODULO (▨▨▨▨▨), CASINFO (▨▨▨▨▨), etc.

You can change the value of VX by storing a new algebraic name in it, e.g., 'x', 'y', 'm', etc. Preferably, keep 'X' as your VX variable for the examples in this manual.

Also, avoid using the variable VX in your programs or equations, so as to not get it confused with the CAS' VX. If you need to refer to the x-component of velocity, for example, you can use vx or Vx.

Selecting the modulus
The *Modulo* option of the CAS MODES input box represents a number (default value = *13*) used in modular arithmetic. More details about modular arithmetic are presented elsewhere.

Numeric vs. symbolic CAS mode
When the *Numeric* CAS mode is selected, certain constants pre-defined in the calculator are displayed in their full floating-point value. By default, the _*Numeric* option is unselected, meaning that those pre-defined constants will be displayed as their symbol, rather than their value, in the calculator display.

The following screen shows the values of the constant π (the ratio of the length of the circumference to its diameter) in symbolic format followed by the numeric, or floating-point, format. This example corresponds to the Algebraic operating mode.

The same example, corresponding to the RPN operating mode, is shown next:

Approximate vs. Exact CAS mode

When the _Approx is selected, symbolic operations (e.g., definite integrals, square roots, etc.), will be calculated numerically. When the _Approx is unselected (Exact mode is active), symbolic operations will be calculated as closed-form algebraic expressions, whenever possible.

The following screen shows a couple of symbolic expressions entered with an active exact mode in Algebraic operating mode:

In Algebraic mode, the object entered by the user is shown in the left-hand side of the screen, followed immediately by a result in the right-hand side of the screen. The results shown above show the symbolic expressions for *ln(2)*, i.e., the natural logarithm of 2, and $\sqrt{5}$, i.e., the square root of 5. If the _Numeric CAS option is selected, the corresponding results for these operations are as follows:
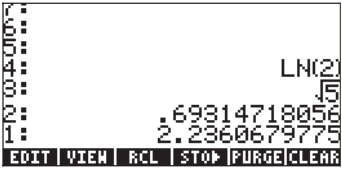
The keystrokes necessary for entering these values in Algebraic mode are the following: ⟨→⟩ _LN ⟨2⟩ ⟨ENTER⟩ ⟨√x⟩ ⟨5⟩ ⟨ENTER⟩

The same calculations can be produced in RPN mode. Stack levels *3:* and *4:* show the case of Exact CAS setting (i.e., the *_Numeric* CAS option is unselected), while stack levels *1:* and *2:* show the case in which the *Numeric CAS* option is selected.

The required keystrokes are: ⟨2⟩ ⟨→⟩ _LN ⟨5⟩ ⟨√x⟩

A keyboard short cut to toggle between APPROX and EXACT mode is by holding the right-shift key and pressing the ENTER key simultaneously, i.e., ⟨→⟩ (hold) ⟨ENTER⟩ .

Real numbers vs. integer numbers

CAS operations utilize integer numbers in order to keep full precision in the calculations. Real numbers are stored in the form of a mantissa and an exponent, and have limited precision. In APPROX mode, however, whenever you enter an integer number, it is automatically transformed into a real number, as illustrated next:

Whenever the calculator lists an integer value followed by a decimal dot, it is indicating that the integer number has been converted to a real representation. This will indicate that the number was entered while the CAS was set to APPROX mode.

It is recommended that you select EXACT mode as default CAS mode, and change to APPROX mode if requested by the calculator in the performance of an operation.

For additional information on real and integer numbers, as well as other calculator's objects, refer to Chapter 2.

Complex vs. Real CAS mode

A complex number is a number of the form *a+bi*, where *i*, defined by $i^2 = -1$ is the unit imaginary number (electrical engineers prefer to use the symbol *j*), and *a* and *b* are real numbers. For example, the number *2 + 3i* is a complex number. Additional information on operations with complex numbers are presented in Chapter 4 of this guide.

When the _*Complex* CAS option is selected, if an operation results in a complex number, then the result will be shown in the form *a+bi* or in the form of an ordered pair *(a,b)*. On the other hand, if the _*Complex* CAS option is unset (i.e., the Real CAS option is active), and an operation results in a complex number, you will be asked to switch to Complex mode. If you decline, the calculator will report an error.

Please notice that, in COMPLEX mode the CAS is able to perform a wider range of operations than in REAL mode, but it will also be considerably slower. Thus, it is recommended that you use the REAL mode as default mode and switch to COMPLEX if requested by the calculator in the performance of an operation.

The following example shows the calculation of the quantity $\sqrt{5^2 - 8^2}$ using the Algebraic operating mode, first with the Real CAS option selected. In this case, you are asked if you want to change the mode to Complex:
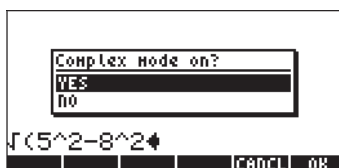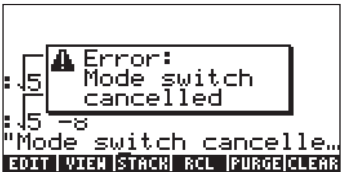
If you press the OK soft menu key (), then the _Complex option is forced, and the result is the following:

$$: \sqrt{5^2 - 8^2}$$
$$i \cdot \sqrt{39}$$

EDIT | VIEW | RCL | STO▶ |PURGE|CLEAR

The keystrokes used above are the following:

$\boxed{\sqrt{x}}$ $\boxed{\leftarrow}$ /_ $\boxed{5}$ $\boxed{\leftarrow}$ $\boxed{y^x}$ $\boxed{2}$ $\boxed{+}$ $\boxed{8}$ $\boxed{\leftarrow}$ $\boxed{y^x}$ $\boxed{2}$ $\boxed{ENTER}$

When asked to change to COMPLEX mode, use: $\boxed{F6}$. If you decide not to accept the change to COMPLEX mode, you get the following error message:

⚠ Error:
Mode switch
cancelled
: √5
: √5 -8
"Mode switch cancelle…
EDIT | VIEW |STACK| RCL |PURGE|CLEAR

Verbose vs. non-verbose CAS mode

When the _Verbose CAS option is selected, certain calculus applications are provided with comment lines in the main display. If the _Verbose CAS option is not selected, then those calculus applications will show no comment lines. The comment lines will appear momentarily in the top lines of the display while the operation is being calculated.
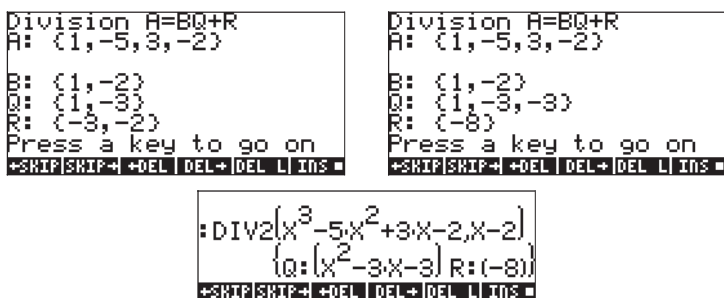
Step-by-step CAS mode

When the _Step/step CAS option is selected, certain operations will be shown step at a time in the display. If the _Step/step CAS option is not selected, then intermediate steps will not be shown.

For example, having selected the Step/step option, the following screens show the step-by-step division of two polynomials, namely, $(X^3-5X^2+3X-2)/(X-2)$. This is accomplished by using function DIV2 as shown below. Press ⟨ENTER⟩ to show the first step:

```
                              Division A=BQ+R
                              A: {1,-5,3,-2}

                              B: {1,-2}
DIV2(X^3-5*X^2+3*X-2,         Q: {1}
X-2)◆                         R: {-3,3,-2}
+SKIP|SKIP→|→DEL|DEL→|DEL L|INS ■    Press a key to go on
                              +SKIP|SKIP→|→DEL|DEL→|DEL L|INS ■
```

The screen inform us that the calculator is operating a division of polynomials A/B, so that A = BQ + R, where Q = quotient, and R = remainder. For the case under consideration, A = X^3-5X^2+3X-2, and B = X-2. These polynomials are represented in the screen by lists of their coefficients. For example, the expression A: {1,-5,3,-2} represents the polynomial A = X^3-5X^2+3X-2, B:{1,-2} represents the polynomial B = X-2, Q: {1} represents the polynomial Q = X, and R:{-3,3,-2} represents the polynomial R = $-3X^2+3X-2$.

At this point, press, for example, the ⟨ENTER⟩ key. Continue pressing ⟨ENTER⟩ the key to produce additional steps:

```
Division A=BQ+R               Division A=BQ+R
A: {1,-5,3,-2}                A: {1,-5,3,-2}

B: {1,-2}                     B: {1,-2}
Q: {1,-3}                     Q: {1,-3,-3}
R: {-3,-2}                    R: {-8}
Press a key to go on          Press a key to go on
+SKIP|SKIP→|→DEL|DEL→|DEL L|INS ■    +SKIP|SKIP→|→DEL|DEL→|DEL L|INS ■
```

```
:DIV2(x^3-5·x^2+3·x-2,x-2)
        {Q:(x^2-3·x-3) R:(-8)}
+SKIP|SKIP→|→DEL|DEL→|DEL L|INS ■
```

Thus, the intermediate steps shown represent the coefficients of the quotient and residual of the step-by-step synthetic division as would have been performed by hand, i.e.,

$$\frac{X^3-5X^2+3X-2}{X-2} = X^2 + \frac{-3X^2+3X-2}{X-2} =$$

$$X^2 - 3X + \frac{-3X - 2}{X - 2} = X^2 - 3X - 3X - \frac{8}{X - 2}.$$

Increasing-power CAS mode

When the _Incr pow_ CAS option is selected, polynomials will be listed so that the terms will have increasing powers of the independent variable. If the _Incr pow_ CAS option is not selected (default value) then polynomials will be listed so that the terms will have decreasing powers of the independent variable. An example is shown next in Algebraic mode:

```
:(X+3)^5
243+405·X+270·X^2+90·X^3+
:(X+3)^5
X^5+15·X^4+90·X^3+270·X^2+4U
EDIT|VIEW|STACK|RCL|PURGE|CLEAR
```

In the first case, the polynomial $(X+3)^5$ is expanded in increasing order of the powers of X, while in the second case, the polynomial shows decreasing order of the powers of X. The keystrokes in both cases are the following:

⟨←⟩ /__ ⟨X⟩ ⟨+⟩ ⟨3⟩ ⟨▷⟩ ⟨Y^x⟩ ⟨5⟩ ⟨ENTER⟩

In the first case the _Incr pow_ option was selected, while in the second it was not selected. The same example, in RPN notation, is shown below:

```
3:
2: 243+405·X+270·X^2+90·X
1: X^5+15·X^4+90·X^3+270·X^2
EDIT|VIEW|STACK|RCL|PURGE|CLEAR
```

The same keystroke sequence was used to produce each of these results:

⟨'⟩ ⟨←⟩ /__ ⟨X⟩ ⟨+⟩ ⟨3⟩ ⟨▷⟩ ⟨Y^x⟩ ⟨5⟩ ⟨ENTER⟩ ⟨EVAL⟩

Rigorous CAS setting

When the _Rigorous CAS option is selected, the algebraic expression |X|, i.e., the absolute value, is not simplified to X. If the _Rigorous CAS option is not selected, the algebraic expression |X| is simplified to X.

The CAS can solve a larger variety of problems if the rigorous mode is not set. However, the result, or the domain in which the result are applicable, might be more limited.

Simplify non-rational CAS setting

When the _Simp Non-Rational CAS option is selected, non-rational expressions will be automatically simplified.   On the other hand, if the _Simp Non-Rational CAS option is not selected, non-rational expressions will not be automatically simplified.

Using the CAS HELP facility

Turn on the calculator, and press the ⌜TOOL⌝ key to activate the TOOL menu. Next, press the ⌜F2⌝ soft menu key, followed by the ⌜ENTER⌝ key (the key in the lowest right corner of the keyboard), to activate the HELP facility. The display will look as follows:

At this point you will be provided with a list of all CAS commands in alphabetical order.   You can use the down arrow key, ▽ , to navigate through the list. To move upwards in the list use the up arrow key, △ . The arrow keys are located on the right-hand side of the keyboard between the first and fourth rows of keys.

Suppose that you want to find information on the command ATAN2S (ArcTANgent-to-Sine function). Press the down arrow key, ▽ , until the command ATAN2S is highlighted in the list:

Notice that, in this instance, soft menu keys `F5` and `F6` are the only one with associated commands, namely:

CANCL `F5`   CANCeL the help facility

OK `F6`   OK to activate help facility for the selected command

If you press the CANCL `F5` key, the HELP facility is skipped, and the calculator returns to normal display.

To see the effect of using OK in the HELP facility, let's repeat the steps used above from to the selection of the command ATAN2S in the list of CAS commands: HELP `F2` `ENTER` ▽ ▽ …(10 times)

Then, press the   OK `F6` key to obtain information about the command ATAN2S.

The help facility indicates that the command, or function, ATAN2S replaces the value of *atan(x)*, the arc tangent of a value *x*, by its equivalent in terms of the function *asin* (arcsine), i.e.,

The fourth and fifth lines in the display provide an example of application of the function ATAN2S. Line four, namely, ATAN2S(ATAN(X)), is the statement of the operation to be performed, while line five, namely, ASIN(X/√(X^2+1)), is the result.

The bottom line in the display, starting with the particle *See:*, is a reference line listing other CAS commands related to the command ATAN2S.

Notice that there are six commands associated with the soft menu keys in this case (you can check that there are only six commands because pressing the ⌐NXT⌐ produces no additional menu items). The soft menu key commands are the following:

▓▓▓▓▓	⌐F1⌐	EXIT the help facility
▓▓▓▓	⌐F2⌐	Copy the example command to the stack and exit
▓▓▓▓▓	⌐F3⌐	See the first link (if any) in the list of references
▓▓▓▓▓	⌐F4⌐	See the second link (if any) of the list of references
▓▓▓▓▓	⌐F5⌐	See the third link (if any) of the list of references
▓▓▓▓▓	⌐F6⌐	Return to the MAIN command list in the help facility

In this case we want to ECHO the example into the stack by pressing ▓▓▓▓ ⌐F2⌐ . The resulting display is the following:

```
:HELP
                        0.
:HELP
:ATAN2S(ATAN(X))
CASCM HELP
```

There are now four lines of the display occupied with output. The first two lines from the top correspond to the first exercise with the HELP facility in which we cancel the request for help. The third line from the top shows the most recent call to the HELP facility, while the last line shows the ECHO of the example command. To activate the command press the ⌐ENTER⌐ key. The result is:

```
:HELP
                        0.
:HELP
:ATAN2S(ATAN(X))
              ASIN⎡ X ⎤
                  ⎣√x²+1⎦
CASCM HELP
```

Notice that, as new lines of output are produced, the display (or stack) pushes the existing lines upwards and fills the bottom of the screen with more output.

The HELP facility, described in this section, will be very useful to refer to the definition of the many CAS commands available in the calculator. Each entry in the CAS help facility, whenever appropriate, will have an example of application of the command, as well as references as shown in this example.

To navigate quickly to a particular command in the help facility list without having to use the arrow keys all the time, we can use a shortcut consisting of typing the first letter in the command's name. Suppose that we want to find information on the command IBP (Integration By Parts), once the help facility list is available, use the ⒜ key (first key in the fourth row from the bottom of the keyboard) followed by the key for the letter i (the same as the key ⒯ᴼᴼᴸ) , i.e., ⒜LPHA ⒤ . This will take you automatically to the first command that starts with an *i*, namely, IBASIS. Then, you can use the down arrow key ▽ , twice, to find the command IBP. Pressing the ▓▓▓ ⒡6 key, we activate the help facility for this command. Press ▓▓▓ ⒡6 to recover the main list of commands, or ▓▓▓ ⒡1 to exit the facility.

### References for non-CAS commands

The help facility contains entries for all the commands developed for the CAS (Computer Algebraic System). There is a large number of other functions and commands that were originally developed for the HP 48G series calculators that are not included in the help facility. Good references for those commands are the *HP 48G Series User's Guide* (HP Part No. 00048-90126) and the *HP 48G Series Advanced User's Reference Manual* (HP Part No. 00048-90136) both published by Hewlett-Packard Company, Corvallis, Oregon, in 1993.

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