Chapter 6

Unit objects

The Units application contains a catalog of 127 units that you can combine with real numbers to create *unit objects*. It also provides you with tools to manipulate unit objects.

The Units application enables you to:

- convert units—for example, you can convert the unit object 10_ft to 120_in or 3.048_m

- factor units—for example, you can factor 20_W with respect to 1_N and return 20_N*m/s

- calculate with units—for example, you can add 10_ft/s to 10_mph and return 16.82_mph.

Overview of the Units application

The calculator's units are based on the 7 base units of the International System of Units (SI): *m* (meter), *kg* (kilogram), *s* (second), *A* (ampere), *K* (kelvin), *cd* (candela), and *mol* (mole). The HP 49G makes use of two additional base units: *r* (radian) and *sr* (steradian). The remaining 118 units are compound units, that is, units derived from the 9 base units.

For example, in (inch) is defined as .0254m, and Fdy (Faraday) is defined as 96487 A*s. (See appendix B of the *User's Guide* for a complete listing of the built-in units and their SI values.)

Units are grouped into the following categories:

length	area	volume	time
speed	mass	force	energy
power	pressure	temperature	electric current
angle	light	radium	viscosity

These categories can be chosen from the Units menu (displayed by pressing ⮕ (UNITS)).

Unit objects

A unit object has two parts: a *real number* and a *unit expression* (a single unit or multiplicative combination of units). The two parts are linked by the underscore character _. For example, 2_in (2 inches) and 8.303_gal/h (8.303 US gallons per hour) are unit objects. Like other object types, a unit object can be placed on the stack, stored in a variable, and used in algebraic expressions and programs.

When you perform a *unit conversion*, the HP 49G replaces the old unit expression with the new unit expression you specify, and automatically multiplies the number by the appropriate conversion factor.

Operators in unit objects follow this order of precedence:

1. ( )

2. ^

3. * and /

For example, 7_m/s^2 is 7 meters per second squared, and 7_(m/s)^2 is 7 square meters per second squared.

To create a unit object

1. Key in the number part of the unit object.

2. Press ⟨⌐⟩ ⟨_⟩.

3. Press ⟨⌐⟩ (UNITS) to display the Units menu.

4. Press ⟨▲⟩ or ⟨▼⟩ until the category of the unit is highlighted.

5. Press OK or (ENTER).

6. Press ⟨▲⟩ or ⟨▼⟩ until the unit is highlighted.

7. Press OK or (ENTER).

8. For compound units, repeat from steps 3 for each additional unit in the unit expression, preceding each with (X), (÷), or (yˣ) as required.

> If you know the unit abbreviation, you can type it directly on the command line instead of selecting it from the Units menu. Note that unit names are case-sensitive; for example, Hz (hertz) must be typed with an uppercase H and a lowercase z.

In addition to the method outlined above, you can create a unit object in RPN mode by assembling it from components on the stack.

To assemble a unit object from the stack

1. Place the number part of the unit object on level 2 of the stack and the unit expression on level 1.

   The unit expression must be in the format *n_unit* where *n* is any real number and *unit* is the unit abbreviation (lb, in, m, etc.).

2. Execute the →UNIT command.

   You can execute the →UNIT command by:

   - pressing ⬚ (UNITS) TOOLS →UNIT
   - selecting it from the commands catalog ((CAT) →UNIT) or
   - pressing ⬚ ⬚ (ALPHA) (ALPHA) UNIT (ENTER).

For example, entering 12 on level 2, 1_ft on level 1 and executing the →UNIT command returns 12_ft.

Unit prefixes

You can also insert a *unit prefix* in front of a unit to indicate a power of ten. The following table lists the available prefixes. (To key in μ, press (ALPHA) ⬚ M.)

Unit Prefixes

Prefix	Name	Exponent	Prefix	Name	Exponent
Y	yotta	+24	d	deci	–1
Z	zetta	+21	c	cent	–2
E	exa	+18	m	milli	–3
P	peta	+15	μ	micro	–6
T	tera	+12	n	nano	–9
G	giga	+9	p	pico	–12
M	mega	+6	f	femto	–15
k or K	kilo	+3	a	atto	–18
h or H	hecto	+2	z	zepto	–21
D	deka	+1	y	yocto	–24

Converting units

The HP 49G provides two commands for converting unit objects from one unit of measurement to another:

- CONVERT
- UBASE.

The CONVERT command—which requires two arguments—can be used to convert one type of unit to *any* other similar unit. The UBASE command—which requires only one argument—is used to convert a unit object to its equivalent SI base unit: feet to metres, knots to metres per second, and so on.

The following examples illustrate how to convert units if you are working in algebraic mode. The steps to follow if you are working in RPN mode are given at the end of the procedure.

To convert from one unit to another

1. Press ⌐ (UNITS) TOOLS CONVERT.
2. Enter the unit object with the units that you want to convert.
   Example: 12_m
3. Press ⌐⌐.
4. Enter a unit object with the units you want the first unit object converted to.
   Example: 1_ft
   It does not matter what value you give to the number part of this unit object.
5. Press (ENTER).
   Example result: 39.3700787402_ft

In RPN mode: follow steps 2, 4, and 1.

If you are converting an angle measurement to units of the same type as your current angle measurement setting, you can omit the unit expression at step 4 above.

For example, if your current angle measurement setting is radians, you can convert 1000_arcmin to radians by entering CONVERT(1000_arcmin, 1) and pressing (ENTER).

To convert units to SI base units

The CONVERT command discussed in the previous section can be used to convert to *any* specified units, SI units or otherwise. If you want to convert a unit object to its equivalent SI base units, the UBASE command is quicker, as it requires just one argument.

1. Press ↱ (UNITS) TOOLS UBASE.

2. Enter the unit object with the units that you want to convert.

    See "To create a unit object" on page 6-2 for instructions on creating unit objects.

    Example: 365_ft

3. Press (ENTER).

    Example result: 111.252_m

In RPN mode: follow steps 2 and 1.

> You can also use the UBASE command to convert an angle measurement unit to radians.

Calculating with units

The HP 49G lets you execute many arithmetic operations with unit objects, just as you would with real numbers:

*   addition and subtraction (dimensionally consistent units only)
*   multiplication and division
*   inversion
*   raising to a power
*   percentage calculations (dimensionally consistent units only)
*   comparisons of values (dimensionally consistent units only)
*   trigonometric operations (planar angular units only)

Where possible, units are automatically converted during the calculation. In such cases, the result is expressed in the units of the last unit object entered.

Note that some operations require certain unit objects to be enclosed in parentheses if you are working in algebraic mode. This is illustrated in the examples given in the next section.

The trigonometric operations SIN, COS, and TAN, operate only on unit objects with *planar angular* units: radians (r), degrees (°), grads (grad), arc-minutes (arcmin), or arc-seconds (arcs).

Temperature units require special attention: see "Working with temperature units" on page 6-8.

Sample unit calculations

The following examples assume that you are working in algebraic mode.

Subtraction. To subtract 39 in from 4 ft:

1. Enter 4_ft.
2. Press ⊖.
3. Enter 39_in.
4. Press (ENTER).

   The answer is 9_in. Note that the answer takes the units of the last entered unit object. If you had subtracted 4 ft from 39 in, the answer would be in feet.

In RPN mode: follow steps 1, 3, and 2.

Unit multiplication and division. To multiply 50 ft by 45 ft and divide the result by 3 days:

1. Enter (50_ft).

   Note that when you are in algebraic mode and multiplying or dividing unit objects, or raising a unit object to a power, the unit object must be entered in parentheses. (The one exception is the last unit object you specify.)
2. Press ⊗.
3. Enter (45_ft).
4. Press ⊘.
5. Enter 3_d.

   Note that the last unit object does not need to be entered in parentheses.
6. Press (ENTER).

   The answer is $750\_ft^2/d$.

In RPN mode: follow steps 1, 3, 2, 5, and 4. Parentheses are not required around unit objects in RPN mode.

Powers. To cube 2ft/s.

1. Enter (2_ft/s).

   Note that when you are in algebraic mode and raising a unit object to a power, the unit object must be entered in parentheses.

2. Press (y^x).

3. Enter 3.

4. Press (ENTER).

   The answer is $8\_ft^3/s^3$

In RPN mode: follow steps 1, 3, and 2. Parentheses are not required around unit objects in RPN mode.

Percentages. To find what percentage of $4.2\,cm^3$ is $1in^3$:

1. Press ⬅ (MTH) REAL %T.

2. Enter 1_in^3.

3. Press ➡ (,).

4. Enter 4.2_cm^3.

5. Press (ENTER).

   The answer is 25.6299725198.

In RPN mode: follow steps 2, 4, and 1.

Factoring unit expressions

The UFACT command factors one unit within a unit object, returning a unit object whose unit expression consists of the factored unit and the remaining SI base units.

To factor units within a unit expression

1. Press ⌐ (UNITS) TOOLS UFACT
2. Enter the unit object with the original units.
   Example: 74_pdl.
3. Press ⌐⌐.
4. Enter any number (such as 1) and attach the units you want to factor out.
   Example: 1_kg.
5. Press (ENTER).
   Answer: 10.2308666238_kgm/s^2.

In RPN mode: follow steps 2, 4, and 1.

Working with temperature units

The HP 49G lets you work with temperature units in the same way that you work with other units. However, you need to be alert to the difference between temperature *level* and temperature *difference*. For example, a temperature *level* of 0°C means "the freezing point of water", but a temperature *difference* of 0°C means "no change."

When °C or °F represents a temperature *level*, the temperature is a unit with an additive constant: 0°C = 273.15 K, and 0°F = 459.67°R. But when °C or °F represents a temperature *difference*, the temperature is a unit with no additive constant: 1°C = 1 K, and 1°F = 1°R.

Converting temperature units

Conversions between the four temperature scales (K, °C, °F, and °R) involve additive constants as well as multiplicative factors. The additive constants are *included* in a conversion when the temperature units reflect actual temperature *levels*, and are *ignored* when the temperature units reflect temperature *differences*.

- **Pure temperature units (levels).** If both unit expressions consist of a single, unprefixed temperature unit with no exponent, the CONVERT command performs an *absolute* temperature scale conversion which includes the additive constants.

- **Combined temperature units (differences).** If either unit expression includes a prefix, an exponent, or any unit other than a temperature unit, the CONVERT command performs a *relative* temperature unit conversion which ignores the additive constants.

The two examples below illustrate these differences.

Example 1:   Convert 25 °C to °F.

1. Press ⟳ (UNITS) TOOLS CONVERT.

2. Enter 25_°C.

3. Press ⟳ (,).

4. Enter 1_°F.

   It does not matter what value you give to the number part of this unit object.

5. Press (ENTER).

   The answer is 77_°F.

In RPN mode: follow steps 2, 4, and 1.

Example 2:   Convert 25°C/min to °F/min.

Note that unlike in the first example, in this example a *relative* temperature conversion will be performed.

1. Press ⌐ [UNITS] TOOLS CONVERT.

2. Enter 25_°C/min.

    Note that °C/min is not available in the units catalog and so must be created. You can select °C from the units catalog, and then press ⊙ and type "min" to complete the compound unit. (Note that *min* must be entered in lower case.)

3. Press ⌐⌐.

4. Enter 1_°F/min.

    It does not matter what value you give to the number part of this unit object.

5. Press [ENTER].

    The answer is 45_°F/min.

In RPN mode: follow steps 2, 4, and 1.