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Metric units and Imperial units

In the Longman Mathematics Handbook (York Press, 1990) the unit is defined as a conventional quantity that is used as a basis for *mensuration*, which is the study of giving numbers to quantities, that is to say, the act of measuring. There are two major system of units, namely the SI system (*Système International d'Unités*) and Imperial units. The latter are based on the pound and the yard, and, despite being replaced by the SI system, are still used in Britain and in the USA (with some differences). On the other hand, the SI system is a system based on these seven basic units: kilograms, meters, seconds, amperes, kelvins, moles and candelas. It is often referred to as the metric system, even though the SI system replaced this former system based on the meter and the gram. Metric units are therefore those based on the meter or belonging to a system of units that is based on the meter. Unit conversion is the change between two measurements of the *same* quantity in different units, and this task plays a lead role in science and engineering.

The CONV menu

The HP 30S provides nine menus of functions for converting to and from metric units. Pressing **CONV** displays the first menu. In order to display the other menus, use the **▲** and **▼** keys. Each menu contains several units, which can be selected by pressing the **◀** and **▶** keys. Note that most menus consist of more units than the ones displayed initially – simply use the **◀** and **▶** keys to display them.

Except for temperatures ($^{\circ}\text{F} = (9/5)^{\circ}\text{C} + 32$), unit conversions involve a multiplication by a conversion factor. These are the 34 units available on your HP 30S, along with the corresponding value in SI units (except for temperatures again) used by the calculator.

Length		Area		Temperature	
cm	0.01 m	feet ²	0.09290304000008 m ²	$^{\circ}\text{F}$	-17.2222222222 $^{\circ}\text{C}$
inch	0.0254 m	yard ²	0.8361273600008 m ²	$^{\circ}\text{C}$	33.8 $^{\circ}\text{F}$
mil	0.0000254 m	m ²	1 m ²		
mm	0.001 m	mile ²	2589988.110336 m ²		
m	1 m	km ²	1000000 m ²		
feet	0.3048 m	hectares	10000 m ²		
yard	0.9144000009144 m	acres	4046.8564224 m ²		
mile	1609.344 m				
km	1000 m				

Volume		Mass		Energy	
gallon	3.785411784001E-3 m ³	Tr.oz	0.03110347680001 kg	kJ	1000 J
liter	0.001 m ³	oz	0.028349523125 kg	Cal	4.186800000009J
B.gal	4.546092000004E-3 m ³	g	0.001 kg	Pressure	
Pint	0.473176473E-3 m ³	pound	0.4535923772575 kg	atm	101325 Pa
fl.oz	0.0295735295625E-3 m ³	lb	0.45359237 kg	kPa	1000 Pa
		kg	1 kg	mmHg	133.322 Pa
				cmH ₂ O	98.06677095777 Pa

Some values are exact (e.g. feet, inch, gallon) while others are provided up to 13 digits of accuracy. On the HP 30S, $^{\circ}\text{F}$ and $^{\circ}\text{C}$ are used for converting temperature *measurements*, not temperature *differences* (see Examples 8 and 9 below). Pound and lb are indeed the same unit, but are in different menus.

HP 30S Solving Problems Involving Unit Conversions

Unlike physics constants (2nd CONST) which can be inserted into the entry line and be part of a calculation, unit conversions can only occur within the CONV menu, but results can be retrieved by the ENTER key and are also stored in ANS. The following examples show the way of converting units using this menu, as well as ways of building up other conversions from the built-in units.

Practice working problems involving conversions

Example 1: Convert 21 yards to meters.

Solution: First of all, the quantity to be converted must be either keyed in into the entry line or already present in the result line, as the result of a previous calculation. Press 2 1 . The ENTER key is not necessary. Now display the CONV menu by pressing CONV , the first length menu (i.e. inch, cm, mm, and mil) is displayed. Since yards are not included in this menu, press \blacktriangledown to display the second length menu (i.e. feet, m, yard, mile, and km). Now, we have to select the unit in which the input quantity is expressed; in our case, we have to select yards: press $\blacktriangleright\blacktriangleright$ to select "Yard" (which will appear underlined). The next step is to press ENTER . The quantity appears in the result line and the selected unit appears underlined. To convert that value, just select the desired unit by pressing the \blacktriangleleft and \blacktriangleright keys. As the selected unit changes, the number in the result line changes accordingly. In this example, we need to find the number of meters corresponding to 21 yards. So press \blacktriangleleft and the result will appear in the result line.

Answer: 19.20240002 m.

Example 2: Add 12.5 meters to 21 yards. Express the result in feet.

Solution: All numbers in the result line are stored in the ANS variable and can be retrieved by the ANS function (2nd ANS). Remember also that ANS is automatically placed in the entry line by two-argument functions if no first argument is supplied. Therefore, since 21 yards expressed in meters are already in the result line from the previous example, to add 12.5 meters we just have to press:

+ 1 2 . 5 ENTER

31.70240002 is displayed in the result line. This quantity is expressed in meters, to convert it to feet press:

CONV $\blacktriangledown\blacktriangleright$ ENTER \blacktriangleleft

In this case, the amount to be converted was the result of a previous calculation.

Answer: 104.0104988 feet.

Example 3: How many gallons is 25 liters?

Solution: First, enter the quantity in liters: CL 2 5 (pressing CL first is necessary to clear the entry line, otherwise 25 would be appended to the last answer). We have to work in the volume menu this time. To display it, press: CONV $\blacktriangle\blacktriangle\blacktriangle$. Once in the proper menu, select "liter" because this is the unit in which the entered quantity 25 is expressed, press \blacktriangleright to underline "liter". Now press ENTER to start the conversion, and select "gallon" by pressing \blacktriangleleft . The answer appears in the result line. Remember that you can now press ENTER to put this number in the entry line or CL to start a new calculation.

HP 30S Solving Problems Involving Unit Conversions

Answer: 6.604301309 gallons.

Example 4: How many cubic inches is 1 gallon?

Solution: The cubic inch is not a built-in unit, but gallons can be easily converted to cubic inches if we remember that there are 1000 cm³ in one liter. These are the calculations involved in this conversion:

$$1 \text{ gallon} = 1 \text{ gallon} \times \frac{3.785411784001 \text{ liters}}{1 \text{ gallon}} \times \frac{1000 \text{ cm}^3}{1 \text{ liter}} \times \frac{(0.3937007874016 \text{ inches})^3}{(1 \text{ cm})^3} = 231 \text{ inches}^3$$

The gallon→liter and cm→inch conversion factors are provided by the HP 30S. When $\boxed{\text{ENTER}}$ is pressed to put the result of a conversion into the entry line, it is the full-precision number that is retrieved, which means that the number in the entry line usually has more decimal digits than the number displayed in the result line, which is limited to ten digits.

Let's evaluate the above expression in two parts. First, find how many cm³ is 1 gallon and store this value into the variable A.

$\boxed{\text{CL}} \boxed{/} \boxed{\text{CONV}} \blacktriangle \blacktriangle \blacktriangle \boxed{\text{ENTER}} \blacktriangleright \boxed{\text{X}} \boxed{\text{E}} \boxed{3} \boxed{\text{STO}} \boxed{\text{ENTER}}$

Now we can complete the conversion multiplying A by the number of cubic inches in one cm³ :

$\boxed{/} \boxed{\text{CONV}} \blacktriangleright \boxed{\text{ENTER}} \blacktriangleleft \boxed{2\text{nd}} \boxed{y^x} \boxed{3} \boxed{\text{VRCL}} \boxed{\text{ENTER}} \boxed{\text{ENTER}}$

Note the implicit multiplication: (0.39...^3)A.

Answer: 231 in³ . Notice that this is an *exact* value, the origin of which is probably a 3 in × 7 in × 11 in rectangular block .

Example 5: Convert 16 square inches into square centimeters.

Solution: In the above example we solved a similar exercise (cm³ to in³), but we'll carry out this conversion using another approach. A square inch is an inch times an inch. After one inch→cm conversion, the units become centimeters times inches. After a second inch→cm conversion, the units become centimeters times centimeters, or square centimeters. So, in this case, conversion to centimeters is carried out *twice*, to give square centimeters:

$\boxed{/} \boxed{6} \boxed{\text{CONV}} \boxed{\text{ENTER}} \blacktriangleright \boxed{\text{ENTER}}$

Note that we must press $\boxed{\text{ENTER}}$ after the first conversion to put the result of the first conversion (40.64) in the entry line, so that the second conversion can use this quantity as an input:

$\boxed{\text{CONV}} \boxed{\text{ENTER}} \blacktriangleright$

which results in 103.2256.

Let's confirm that this result is correct by doing the following calculation:

$$16 \text{ inches}^2 = 16 \times 1 \text{ inch}^2 \times \frac{(2.54 \text{ cm})^2}{(1 \text{ inch})^2}$$

where the quantity 2.54 is provided by the HP 30S doing:

CL **/** **CONV** **ENTER** **▶** **ENTER**

Once this conversion factor is in the entry line, we have to take the square and multiply by 16:

x² **/** **6** **ENTER**

We obtain the same result, which confirms that the method used above is correct.

Answer: 103.2256 in²

Special care must be taken with temperature conversions. Temperature conversions on the HP 9s are based on temperature *levels*. This preserves mathematical commutativity of addition, but does not always match engineering needs. Engineers often distinguish between a point on a temperature scale (degree Fahrenheit) and a distance (or *difference*) along that scale (Fahrenheit degree). A temperature level of 0°C means “freezing,” but a temperature difference of 0°C means “no change.” The following examples try to illustrate this difference.

Example 6: The HP-67 programmable pocket calculator was designed to retain the contents of its memory at temperatures as low as –40°C. What is –40 degrees Celsius in Fahrenheit?

Solution: This conversion can be solved using the CONV menu:

CL **+/-** **4** **0** **CONV** **▲▲▲▲** **▶** **ENTER** **◀**

Answer: –40°F. That is not an error—this example shows that at –40 degrees the Celsius and Fahrenheit scales coincide.¹

Example 7: Determine if 25°C is greater than 75°F.

Solution: This is another example of temperature levels. Let's convert the latter to Celsius by pressing:

CL **7** **5** **CONV** **▲▲▲▲** **ENTER** **▶**

Answer: 75°F is 23.89°C, therefore 25°C is greater than 75°F.

Example 8: The temperature *range* in a certain region is 83°F°. Express this range in Celsius degrees.

Solution: Since we are converting ranges or differences of temperatures, we cannot use the built-in conversion functions. Instead, let's use the following identity:

¹ Temp. Fahrenheit = 1.8 · Temp. Celsius + 32. Therefore, Temp. Fahrenheit = Temp. Celsius = T when T = 1.8 · T + 32 ⇒ T = 32 / (1 – 1.8) = – 40.

$$5^{\circ}\text{C} = 9^{\circ}\text{F}$$

Therefore, $83^{\circ}\text{F} = 83 \cdot \frac{5}{9}^{\circ}\text{C}$. Press:

CL **8** **3** **X** **5** **÷** **9** **ENTER**

Answer: 83°F is 46.11°C .

Example 9: An experimental new heater is designed to raise the temperature of its surroundings by exactly 20 Celsius degrees and then to turn itself off. If the heater is working correctly, what should the temperature be, in degrees Fahrenheit, after the heater is used in a room initially at a temperature of 50 degrees Fahrenheit?

Solution: Once again, a temperature *difference* of 20 Celsius degrees is not the same as a temperature of 20 degrees Celsius. A temperature of 20 degrees Celsius is 68 degrees Fahrenheit :

CL **2** **0** **CONV** **▲▲▲▲▶** **ENTER** **◀**

The temperature difference can be calculated as 20 *times 9 divided by 5*, giving 36 Fahrenheit degrees. Adding this to 50 will give 86 degrees Fahrenheit:

CL **2** **0** **X** **9** **÷** **5** **+** **5** **0** **ENTER**

Alternatively, the conversion functions can be used to calculate this as follows. First of all, do the conversion $50^{\circ}\text{F} \rightarrow ^{\circ}\text{C}$ then add 20 and finally convert the result back to Fahrenheit:

5 **0** **CONV** **▲▲▲▲▶** **ENTER** **▶** **ENTER** **+** **2** **0** **CONV** **▲▲▲▲▶** **ENTER** **◀**

Note that completing the addition by pressing **ENTER** is not necessary because the functions of the CONV menu take their arguments *evaluating* the entry line (or from the result line if it is present).

Answer: 86 degrees Fahrenheit.