hp calculators

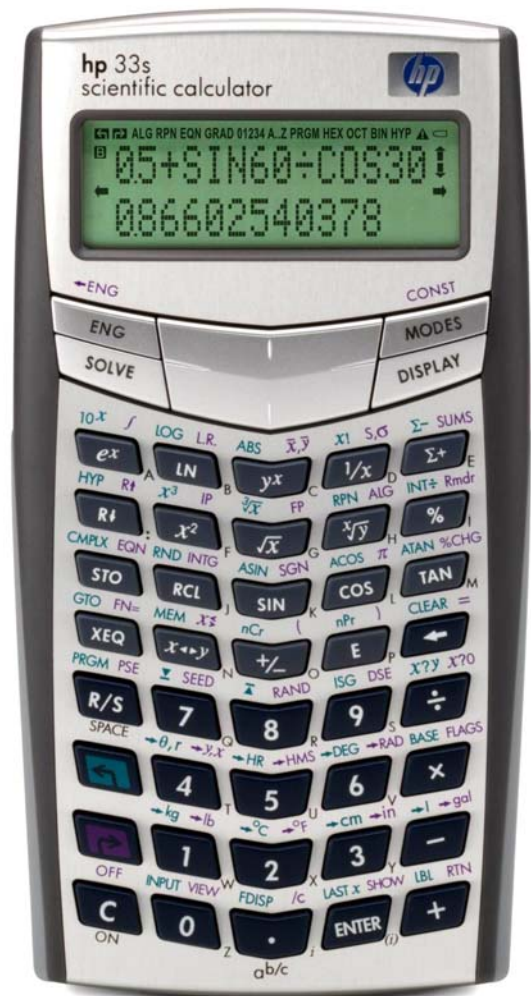## HP 33S Temperature Conversions

Metric units and Imperial units

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Conversion of temperatures and conversion of temperature differences

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Using equations and programs for complicated conversions

Metric units and Imperial units

Measurements of quantities such as length, mass or temperature use units. Metric units include centimeters and meters, grams and kilograms, or Celsius and Kelvin degrees. Imperial units include feet and yards, ounces and pounds, or Fahrenheit and Rankine degrees. The HP33S provides eight functions for converting to and from Metric units. These conversions are useful for many problems in engineering, mathematics, and physical and biological sciences. They can also be used to create additional conversions, through HP33S equations and programs.

Two training aids describe unit conversions on the HP33S. This training aid covers conversion of temperature units in detail. The other training aid on unit conversions describes mass, length and volume conversions, and gives a simple example of temperature conversion. For coordinate, angle and time conversions see the separate training aids, for example angle conversions are covered in the training aid on angle conversions and angle arithmetic.

Conversion keys

The unit conversion functions are on the right and left shifted ①②③ and ⊟ keys. The available conversions are as follows:

> ◀ →kg for pounds to kilograms
> ▶ →lb   for kilograms to pounds
> ◀ →°C for Fahrenheit to Centigrade
> ▶ →°F for Centigrade to Fahrenheit
> ◀ →cm for inches to centimeters
> ▶ →in   for centimeters to inches
> ◀ →l   for gallons to liters, and
> ▶ →gal for liters to gallons.

The right and left shifted functions on each key are the inverse of each other. Ways to perform other conversions, not on these keys, are shown below.

Note that conversions *to* Metric units are always on the left-shifted leys, and conversions *from* Metric units are on the corresponding right-shifted keys.

Conversions of lb/kg, of in/cm, and of gal/l involve only multiplication by a conversion factor. Conversions of °F/°C require addition or subtraction of offset constants as well as multiplication, and are therefore described separately, in this training aid, in more detail.

Practice working problems involving temperature conversions

Special care must be taken with temperature conversions. The two commands →°C and →°F convert *temperatures*, as the first two examples below show, but they do not convert temperature differences.

Example 1:   Many photographic film developers are designed to work best at 20 degrees Celsius. What is 20 degrees Celsius in Fahrenheit?

Solution: In RPN mode, type the number 20 and then press the right-shifted ② key.

> ② ⓪ ▶ →°F

In Algebraic mode, do the same. Pressing $\boxed{\text{ENTER}}$ completes the calculation, but is not necessary unless the conversion comes at the end of a longer calculation.

$\boxed{2}\boxed{0}\boxed{\rotatebox{90}{▸}}\boxed{\text{→°F}}\boxed{\text{ENTER}}$

```
ALG
20→°F
68
```
Figure 1

Answer: 20 degrees Celsius is 68 degrees Fahrenheit.

Example 2:   What is –40 degrees Fahrenheit when measured in degrees Celsius?

Solution: In RPN mode, type the number 40, change the sign, and then press the left-shifted $\boxed{2}$ key.

$\boxed{4}\boxed{0}\boxed{+/-}\boxed{\blacktriangleleft}\boxed{\text{→°C}}$

In Algebraic mode, do the same. Again, pressing $\boxed{\text{ENTER}}$ completes the calculation, but is not necessary unless the conversion is part of a longer calculation.

$\boxed{4}\boxed{0}\boxed{+/-}\boxed{\blacktriangleleft}\boxed{\text{→°C}}\boxed{\text{ENTER}}$

```
ALG
-40→°C
-40
```
Figure 2

Answer: The result is –40. That is not an error – this example shows that at –40 degrees the Celsius and Fahrenheit scales coincide.

Conversion of temperatures and conversion of temperature differences

With most measurements, zero is an absolute minimum. A length of zero inches or zero centimeters is the smallest possible length, and zero is zero in either of these units. Temperatures are different. Zero degrees Celsius is the freezing point of water at Standard Pressure, but the lowest possible temperature is Absolute Zero, –273.15 degrees Celsius. In degrees Fahrenheit, the freezing point of water is 32 degrees, and Absolute Zero is –459.67 degrees Fahrenheit.

This means that a conversion from a measurement of 20°C to Fahrenheit requires multiplication by 9/5 because 5 degrees Celsius are the same size as 9 degrees Fahrenheit, but then addition of 32 because 0°C is 32°F. As Figure 3 shows, this gives the correct answer of 68 degrees Fahrenheit, obtained in Example 1. The opposite is needed for conversion from Fahrenheit to Celsius, first subtraction of 32, then multiplication by 5/9. The $\boxed{\text{→°C}}$ and $\boxed{\text{→°F}}$ functions automatically carry out these calculations.

```
ALG
20×9÷5+32=
68
```
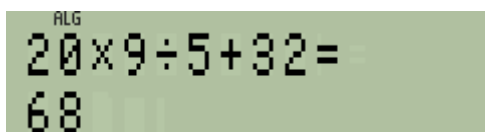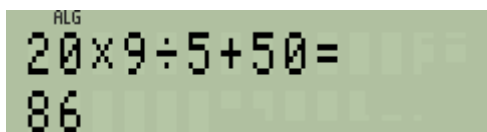Figure 3

As opposed to a temperature measurement, a temperature difference of zero really is zero, and does not need the addition or subtraction of 32. Adding 5 Celsius degrees to 20°C is the same as adding 9 Fahrenheit degrees to 68°F and does not require addition or subtraction of 32.

Note: To make clear the distinction between temperature measurement and temperature difference, temperature measurements are usually called "degrees Celsius" or "degrees Fahrenheit", and temperature differences are called "Celsius degrees" or "Fahrenheit degrees".

Because the ➜°C and ➜°F functions convert temperature measurements, not temperature differences, conversion of differences must be dealt with either by a manual conversion, using the factor 5/9,or by the addition of a temperature difference to a temperature only on the same scale.

Example 3:   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: 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, as Example 1 showed. 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. Figure 4 shows this calculation in Algebraic mode.
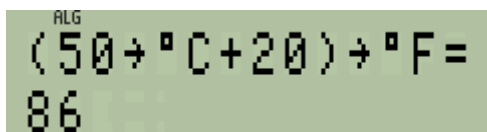

Figure 4

Alternatively, the conversion functions can be used to calculate this as follows.

In RPN mode, type the number 50, and press the left-shifted ⬛2⬛ key to convert it to Celsius. Then add 20 Celsius degrees. Finally convert back to Fahrenheit.

⬛5⬛ ⬛0⬛ ⬛◁⬛ ⬛➜°C⬛ ⬛2⬛ ⬛0⬛ ⬛+⬛ ⬛▷⬛ ⬛➜°F⬛

In Algebraic mode, do the conversion, in parentheses, then add 20 in algebraic order, and close the parentheses, then convert the completed addition back to Fahrenheit. In this case, pressing ⬛ENTER⬛ is again not required to complete the calculation.

⬛(⬛ ⬛5⬛ ⬛0⬛ ⬛◁⬛ ⬛➜°C⬛ ⬛+⬛ ⬛2⬛ ⬛0⬛ ⬛)⬛ ⬛▷⬛ ⬛➜°F⬛ ⬛ENTER⬛

Figure 5

Answer: As figures 4 and 5 show, the correct answer is 86 degrees Fahrenheit.

Other temperature scales

A temperature scale with 100 degrees between two points is called a centigrade scale ("centigrade" means one hundred degrees), and is an obvious scale for use in the metric system where measurements are based on powers of 10. A scale with 0 at the freezing point of water and 100 at the boiling point was suggested by Celsius, and is now called the Celsius scale. The Fahrenheit scale is the best known alternative, but some old textbooks (especially French ones) use the Reaumur scale, with the freezing point of water at 0 degrees and the boiling point at 80 degrees.

The Kelvin and Rankine temperature scales avoid the complication of Absolute Zero not being called 0. Kelvin degrees are the same size as Celsius degrees, but Absolute Zero is 0 degrees Kelvin. Rankine degrees are the same size as Fahrenheit degrees but again Absolute Zero is 0 degrees Rankine.

Temperatures can therefore be converted using these expressions:

$$T°K ≡ T°C + 273.15°C$$

$$T°R ≡ T°F + 459.67°F$$

$$T°K ≡ T°R × 5/9$$

The symbol ≡ means "is equivalent to", so the first expression means that a temperature of T°C can be converted to an equivalent temperature in degrees Kelvin by the addition of 273.15.

Using equations and programs for complicated conversions

For complicated conversions, it can be useful to write an equation or a program to do the conversion automatically.

Example 4:   Write an equation to convert degrees Fahrenheit to degrees Kelvin.

Solution: Assume that the temperature in Fahrenheit will be in the variable F. To enter the equation, equation mode is first entered by pressing ◄ꜱ EQN, and the expression is typed as follows:
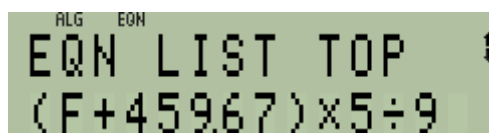
◄ꜱ (RCL F + 4 5 9 · 6 7 ◄ꜱ) × 5 ÷ 9

EQN LIST TOP
(F+459.67)×5÷9   Figure 6

Answer: Figure 6 shows the required equation entered on the HP33S.

Example 5:   Use the equation from example 4 to convert 90 degrees Fahrenheit to degrees Kelvin.

Solution: If equation mode is not already set following Example 4 then set equation mode by pressing ◄ꜱ EQN. If other equations are stored in the calculator, it might be necessary to use the up or down cursor keys to select the equation that was typed above. Then press ENTER to use the equation. A prompt for F will be displayed.

ALG   EQN

F?

0

Figure 7

9 0 R/S should be typed, and the equation will run for a moment, then the answer will be displayed.

ALG

305.372222222

Figure 8

Answer: The answer, 305.372 degrees Kelvin, is displayed.

The equation can now be used again to convert a different temperature from degrees Fahrenheit to degrees Kelvin. Press $\boxed{\leftarrow}$ EQN, to enter equation mode again, press $ENTER$ to start the equation again, type the temperature in degrees Fahrenheit, and press R/S to carry out the calculation.

Programs can be used instead of equations if the user prefers to use programs or if the additional power of program commands such as test and loops is needed. How to write programs is described in a separate training aid.