

TEMPERATURE SCALES AND CONVERSIONS

Temperatures are measured by one of four basic scales, namely, Centigrade, Fahrenheit, Kelvin, and Rankine. We want in this brief note to define these scales and provide the necessary formulas relating them to each other.

CELSIUS- Also known as Centigrade was discovered and first used by the Swedish astronomer, physicist and mathematician Anders Celsius (1701-1744). As a professor at the University of Uppsala, he was the first to design and build a new thermometer where zero was the freezing point of water and 100 its boiling point. He made numerous additional contributions to science including the measurement of star brightness. Unfortunately he died of tuberculosis at the very young age of 43.

FAHRENHEIT-This temperature scale was discovered by Daniel Fahrenheit (1686-1736). He was of German ethnicity born in Danzig (now Poland). As a teenager he moved to the Netherlands where he developed a scientific instrument business and especially designed precision thermometers using mercury as the expanding fluid. His new temperature scale put the freezing point of pure water at 32 and its boiling point 180 degrees higher at 212. His original idea was to put body temperature near 100 on his scale. He was elected a Fellow of the Royal Society in 1724. Unfortunately he died quite young believed due to his extensive handling of mercury and his glass blowing endeavors.

KELVIN- This temperature scale is named in the honor of William Thompson (1824-1907) later known as Lord Kelvin. He was a mathematical physicist and researched disparate areas such as hydrodynamics, electricity and magnetism and the theory of heat. Also he made calculations concerning the age of the earth plus in 1848 proposed an absolute temperature scale where zero lies at -273.15°C so that $K=C+273.15$. He was involved in the laying of the first transatlantic cable. Most of his academic career after graduating from Cambridge was spent at the University of Glasgow. He travelled widely throughout Western Europe and visited the United States several times to present lectures. He is buried in Westminster Abby.

RANKINE-This is an absolute temperature scale(R) related to Fahrenheit (F) via the formula $R=F+459.67$. It is named in honor of the Scottish civil and mechanical engineer and polymath William Rankine(1820-1872). He was a civil engineer working first in industry and later as a professor at the University of Glasgow. He made numerous scientific and engineering contributions over a wide range of fields in his short and unmarried lifetime . His interests also extended outside of engineering including music and mathematics. Today he is best known for the invention of the Rankine Cycle in thermodynamics.

CONVERSION FORMULAS- As we have already shown above there are four standard temperature scales used throughout the world. These are Celsius (C), Fahrenheit (F),

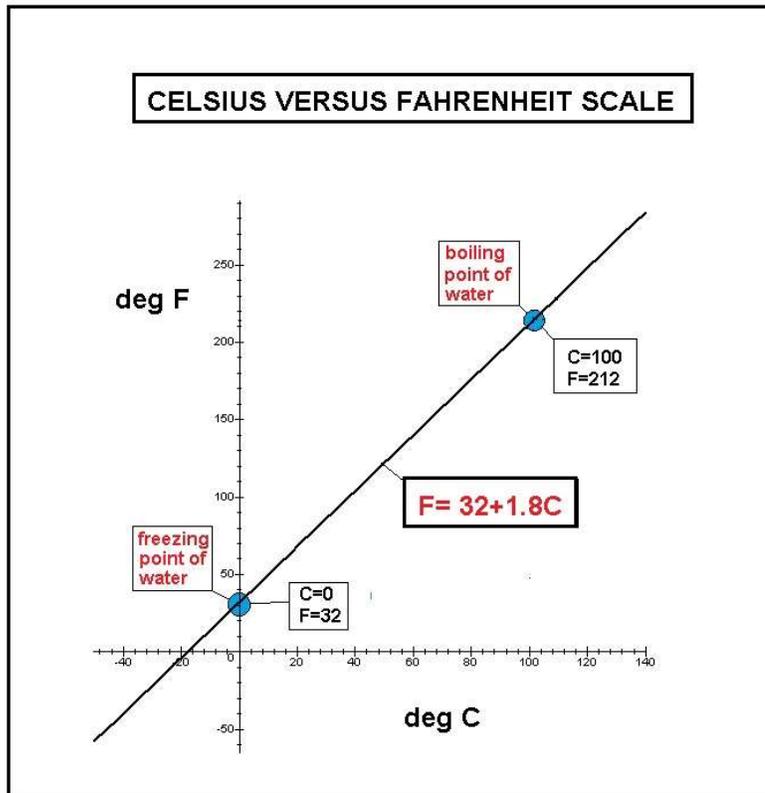
Kelvin(K), and Rankine(R). To go from one to another we need only remember that water freezes at $0^{\circ}\text{C} = 32^{\circ}\text{F}$, *boiling water occurs at $100^{\circ}\text{C} = 212^{\circ}\text{F}$* , and *absolute zero is found at $-273.15^{\circ}\text{C} = -459.67^{\circ}\text{F}$* . From these equalities we see at once that the ratio of *Fahrenheit to Celsius is $180/100 = 1.8$* . Assuming a linear expansion rate in the thermometer tube we get the conversion formula

$$^{\circ}\text{F} = 32 + 1.8^{\circ}\text{C}$$

This produces the table-

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|--------------------|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|
| $^{\circ}\text{C}$ | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| $^{\circ}\text{F}$ | 32 | 55 | 68 | 86 | 104 | 122 | 140 | 158 | 176 | 194 | 212 |

Yesterday we had the hottest day of the year here in Gainesville. It was 96°F which converts to 35.6°C . A graph of F versus C follows-



This linear relation between Fahrenheit and Celsius in this graph is sufficiently simple that one can work out the conversion in one's head, For instance, let's say we want to convert the highest ever recorded and verified temperature in Death Valley of 130 degrees Fahrenheit to Centigrade, we would work things out as $5(130-32)/9 \sim 54^{\circ}\text{C}$. Another question one could ask is - At what temperatures are the F and C values equal? The answer is $(5-9) F=5(32)$ or $F=C= -40$.

We can also read-off directly from the graph that Fahrenheit's salt water solution freezes at -18 °C. This lowering of the freezing point is the reason utilities in northern states spray their ice covered roads with salt.

To convert to Kelvin and Rankine scales we just keep in mind that K relates directly with C and R with F. The differences are $K-C=273.15$ and $R-F=459.67$. Consider now the conversion of the boiling point of liquid nitrogen at 77.2 degree Kelvin. Here we get –

$$-273.15+77.2= -195.95^{\circ}\text{C} \quad \text{and} \quad -459.67+138.96= -320.79^{\circ}\text{F}$$

with

$$1.8*77.2=138.96 \text{ degree Rankine at the boiling point of nitrogen.}$$

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