Just In Time Physics: Temperature Scales

Heat and temperature are not the same thing. A match and a forest fire may well be at the same temperature, but the forest fire contains a lot more heat. Heat is a measure of how much energy is there, and heat is real. Heat is what bakes your bread, warms your house, and turns winter into summer. By contrast, temperature is just a number that tells you where the heat wants to go. Most people don't think of temperature in these terms, but to a physicist, that's exactly what temperature is. Heat always "flows from hotter to colder", and when you say that, what you really mean is that heat always flows from spots with higher temperatures to spots with lower temperatures. A raging forest fire contains much more heat than a tiny white-hot incandescent light-bulb filament, but nonetheless, heat will flow away from the light bulb filament and towards the forest fire because the white-hot filament is at a higher temperature.

Temperature is usually measured on one of three scales: the Fahrenheit, the Celsius (or centigrade), and the absolute (or Kelvin) scale. The only differences between these scales is where they place the zero value and how big the degrees are. The Fahrenheit scale is used more-or-less nowhere except in the United States. (The Cayman Islands and Belize, of all places, still use it, and it also shows up now and then in the United Kingdom and Canada.) This scale was created in 1724 by German physicist and instrument maker Daniel Fahrenheit, who decided to place his zero value at the coldest value he could easily generate, which was that of freezing salt water. (Hence zero on the Fahrenheit scale is roughly where the salt that they spread on streets in the winter stops being effective.) Fahrenheit decided that he would make 96 degrees on his scale equal to the human body temperature, primarily because 96 divided by three is exactly 32 degress, which is the freezing point of pure water on the Fahrenheit scale. Over time, the scale has been adjusted slightly so that today standard body temperature is accepted to be 98.7 F°.

The Celsius scale was first proposed in 1742 by Swedish astronomer Anders Celsius. On his scale, zero was the freezing point of pure water, and 100 degrees was where pure water boils if it is at sea level. (The exact, technical definition of the modern Celsius scale is slightly different from this, but never mind. The essence has not changed.) The Celsius scale is used virtually everywhere to measure daily temperatures except in the United States, which clings to Fahrenheit exactly as stubbornly as it clings to English units. One can convert Fahrenheit degrees into Celsius by using the little formula C = (F – 32) / 1.8, and contrawise, convert Celsius into Fahrenheit using F = 1.8 C + 32. (If you are familiar with algebra, then you can amuse yourself by setting x = F = C and solving either equation to discover that the Fahrenheit and Celsius scales coincide with each other at F = C = –40°.)

The absolute or Kelvin scale requires a bit more discussion. Scientists in the 18th century had noticed that materials tend to expand when they are heated and to contract when they are cooled. In particular, experiments initiated by French chemist Jacques Charles of France and then extended by others on the cooling of

gasses had shown that all gasses – regardless of their composition – contract by 1/273 of their volume for each degree Celsius that they are cooled below 0 C°. If taken to its logical limit, this experimental result therefore implies that all gasses should disappear altogether if cooled to –273 C°!

–273 C° is a bitterly cold temperature (equivalent to –460 F°) and was far beyond the refrigeration capabilities of the 18th century, so this fantastic-sounding prediction could not immediately be put to the test. It was left to the English physicist William Thompson (aka Lord Kelvin) to recognize that –273 C° did not represent a ridiculous point where the gasses would disappear, but rather, a perfectly logical point where the gasses would be so cold that the individual atoms would stop moving. Since heat is nothing more than the microscopic movements of atoms, he reasoned, there obviously cannot be any temperature colder than when the atoms aren't moving at all, thus –273 C° eventually came to be known as *absolute zero*, the coldest possible temperature. (Actually, to be exact, absolute zero is at –273.16 C°, but almost everybody rounds it off to –273 C°.)

The absolute, or Kelvin scale of temperature is the same as the Celsius scale except that rather than using the freezing point of water as its zero point, it uses absolute zero for 0 K°, hence its name. The Kelvin scale is widely used in physics because a scale that starts at the coldest possible temperature and only goes up, without having any negative temperatures, is very convenient in many physical situations. In particular, there are many formulas in physics involving temperature which simply do not work unless the temperature is measured in K°.