

Temperature

We know very well that a hot object has higher **temperature** than a cold one. So, the higher temperature of something hotter than something is. But it is much more difficult to explain what the temperature is. What is the physical meaning of this parameter? We know that all the objects around us consist of small particles which move chaotically all the time. Temperature of the object is proportional to the **average kinetic energy of the particles (atoms of molecules) of the object**. If we are cooling down, say, a glass of water, molecules of water are slowing down and losing their kinetic energy (they transfer it to another object – an ice cube, for example).

Temperature scales. To define a scale, we need to set up two reference points and assign two different temperatures to them. A convenient choice is to use freezing point of fresh water as one reference point and boiling point of water as the other reference point. In **Celsius** scale freezing point of water is assigned 0° C and boiling point of water is 100° C so these water reference points are really built in it.

The first person who produced thermometer with reliable operation and reproducible readings was Daniel Gabriel **Fahrenheit** – German physicist and engineer.

To recalculate Fahrenheit temperature into the Celsius temperature we must:

1. Take the temperature in Fahrenheit degrees and subtract 32.
2. Multiply the result by 5 and divide by 9 – you have the Celsius temperature.

$$t_F = 32 + \frac{9}{5}t_C$$

The **Kelvin scale is the scale used in physics**. One degree of the Kelvin scale is equal to 1 Celsius degree, but 0°C corresponds to 273 degrees at the Kelvin scale (we write 273K). So, a 100° C (water boiling point) becomes 373K. The general relation between Celsius and Kelvin scales is therefore:

$$T = t_c + 273$$

where T is temperature in Kelvins and t_c is the corresponding temperature in Celsius.

Relating internal kinetic energy and temperature. Kelvin scale is especially convenient for relating temperature and average internal kinetic energy of atoms and molecules. This relation is as follows:

$$E_{\text{kin}} = \frac{3}{2} kT,$$

T is temperature in Kelvins and $k = 1.38 \cdot 10^{-23}$ J/K is called the Boltzmann constant. Boltzmann constant is the coefficient between average internal kinetic energy of atoms and molecules and temperature. It is a very small number, so kinetic energies of atoms and molecules are very small. But this is what you should expect, because their mass is very tiny.

Homework:

- 1) Is there a temperature which is the same on both Fahrenheit and Celsius scales? – (This problem is more about math than physics).
- 2) What is the temperature of a human body according to the Kelvin scale?
- 3) Find the average speed of motion of oxygen molecules in air at temperature 300 K (this is often taken as the value of typical room temperature, because the number is nice). Mass of the oxygen molecule is $m_{O_2} = 2.7 \cdot 10^{-26}$ kg.