Temperature

A Galileo thermometer consists of a sealed glass cylinder filled with a transparent liquid and containing a number objects of varying densities. These objects rise or fall as the temperature of the liquid in changes. (Image Source: Wikimedia Commons).

Temperature and Heat

Temperature is a measure of the intensity or degree of hotness in a body.

Temperature and heat are not the same phenomenon. Technically, temperature is determined by getting the average speed of a body's molecules. Heat is a measure of the quantity of heat energy present in a body. The spatial distribution of temperature in a body determines heat flow. Heat always flows from warmer to colder areas.

Table 1: Heat energy required to raise two different quantities of water 5° Celsius.

Mass of the Water	**Starting Temperature**	**Ending Temperature**	**Heat Required**
5 grams	20° Celsius	25° Celsius	25 Calories of Heat
25 grams	20° Celsius	25° Celsius	125 Calories of Heat

The heat held in an object depends not only on its temperature but also its mass. For example, let us compare the heating of two different masses of water (Table 1). In this example, one mass has a weight of 5 grams, while the other is 25 grams. If the temperature of both masses is raised from

20 to 25° Celsius, the larger mass of water will require five times more heat energy for this increase in temperature. This larger mass would also contain 5 times more stored heat energy.

Temperature Scales

A number of measurement scales have been invented to measure temperature. Table 2 describes important temperatures for the three dominant scales in use today.

Table 2: Temperature of absolute zero, the ice point of water, and the stream point of water using various temperature measurement scales.

Measurement	**Steam Point of Water**	**Ice Point of Water**	**Absolute Zero**
Fahrenheit	212	32	-460
Celsius	100	0	-273
Kelvin	373	273	0

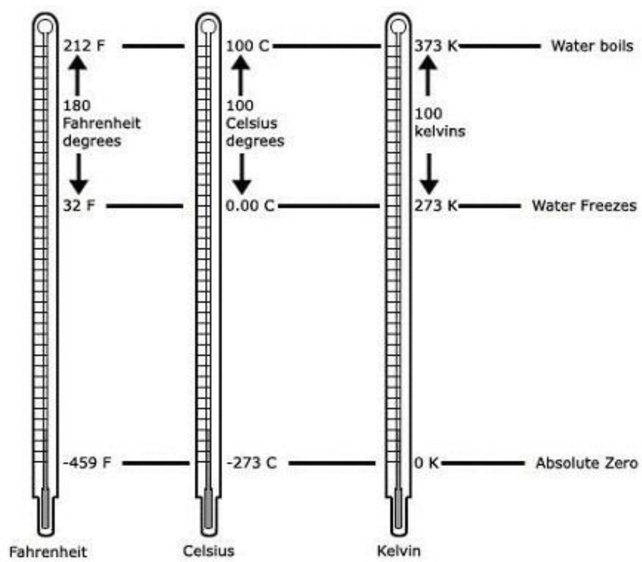


Figure 1: Comparison of the Fahrenheit, Celsius and Kelvin temperature scales. (Source: NASA).

The most commonly used scale for measuring temperature is the Celsius system (Figure 1). The Celsius scale was developed in 1742 by the Swedish astronomer Anders Celsius. In this system, the melting point of ice was given a value of 0, the boiling point of water a value of 100, and absolute zero a value of -273.

The Fahrenheit system is a temperature scale that is used exclusively in the United States. This system was created by German physicist Gabriel Fahrenheit in 1714. In this scale, the melting point of ice has a value of 32, water boils at 212, and absolute zero has a temperature of -460.

The Kelvin scale was proposed by British physicist Lord Kelvin in 1848. This system is often used by scientists because its temperature readings begin at absolute zero and due to the fact that this scale is proportional to the amount of heat energy found in an object. The Kelvin scale assigns a value of 273 for the melting temperature of ice, while the boiling point of water occurs at 373.

Conversion of temperature scales

Table 3: Temperature Conversions

Scale	To Kelvin	From Kelvin
Celsius	K = °C + 273.15	°C = K − 273.15
Fahrenheit	K = (°F + 459.67) ÷ 1.8	°F = (K × 1.8) − 459.67
Rankine	K = °R ÷ 1.8	°R = 1.8 × K

Scale	To Celsius	From Celsius
Fahrenheit	°C = (°F − 32) ÷ 1.8	°F = (1.8 × °C) + 32
Rankine	°C = (°R ÷ 1.8) − 273.15	°R = 1.8 × (°C + 273.15)
Kelvin	°C = K − 273.15	K = °C + 273.15

Scale	To Rankine	From Rankine
Celsius	°R = 1.8 × (°C + 273.15)	°C = (°R ÷ 1.8) − 273.15
Fahrenheit	°R = °F + 459.67	°F = °R − 459.67
Kelvin	°R = 1.8 × K	K = °R ÷ 1.8

Scale	To Fahrenheit	From Fahrenheit
Celsius	°F = (1.8 × °C) + 32	°C = (°F − 32) ÷ 1.8
Rankine	°F = °R − 459.67	°R = °F + 459.67
Kelvin	°F = (1.8 × K) − 459.67	K = (°F + 459.67) ÷ 1.8

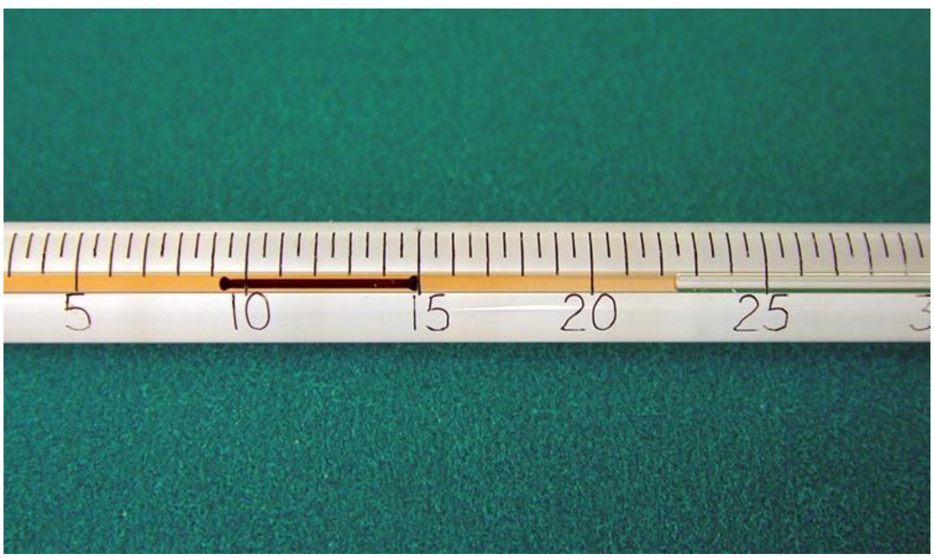
Measurement of Air Temperature

A thermometer is a device that is used to measure temperature. Thermometers consist of a sealed hollow glass tube filled with some type of liquid. Thermometers measure temperature by the change in the volume of the liquid as it responds to the addition or loss of heat energy from the environment immediately outside its surface. When heat is added, the liquid inside the thermometer expands. Cooling causes the liquid to contract. Meteorological thermometers are often filled with either alcohol or mercury. Alcohol thermometers are favored in very cold environments because of this liquid's low freezing point (-112° Celsius).

By international agreement, the nations of the world have decided to measure temperature in a similar fashion. This standardization is important for the accurate generation of weather maps and forecasts, both of which depend on having data determined in a uniform way. Weather stations worldwide try to determine minimum and maximum temperatures for each and every day. By averaging these two values, daily mean temperatures are also calculated. Many stations also take temperature readings on the hour. Temperature measurements are determined by thermometers designed and approved by the World Meteorological Organization. These instruments are housed in specially designed instrument shelters that allow for the standardization of measurements taken anywhere on the Earth (Figures 2, 3 and 4).

Figure 2: Stevenson Screen meteorological instrument shelters. These shelters are typically made of wood, painted white, and have louvered sides. They also are elevated to height of about 1.5 meters (about 4.5 feet) by a wooden or metal base. Some instrument shelters have an electric fan attached to them for better air circulation in the instrument box during light wind conditions. (Image Copyright: Michael Pidwirny).

Figure 3: Thermometers found inside the instrument shelter are mounted approximate 1.5 meters above the ground surface. The top thermometer contains alcohol and is used to determine daily minimum temperatures. The lower thermometer uses mercury to determine the daily maximum temperature. (Image Copyright: Michael Pidwirny).



Further Reading

- PhysicalGeography.net
- World Meteorological Organization Homepage

- J.Serrin. (1986). Chapter 1, 'An Outline of Thermodynamical Structure', pages 3-32, especially page 6, in*New Perspectives in Thermodynamics*, edited by J. Serrin, Springer, Berlin, ISBN 3-540-15931-2.
- J.C.Maxwell (1872). *Theory of Heat*, third edition, Longmans, Green, London, page 32.

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