

1. MEASUREMENT

In everyday life, measurements are often necessary. For instance,

- The amount of cloth required for a dress,
- The weight of grocery and vegetables to be bought,
- The amount of sugar needed for a cup of tea or amount of petrol to fill in a car are all measured.

Every **measurement involves a number and a unit.**

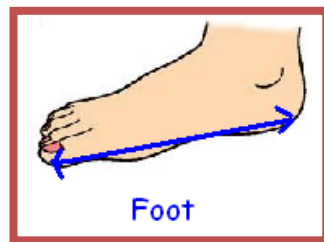
Example: Assume that your classroom measures 10 meters in length. The number here is 10 and the unit is meter.

Measurement means the comparison of an **unknown** quantity with some **known** quantity. This known fixed quantity is called a **unit**.

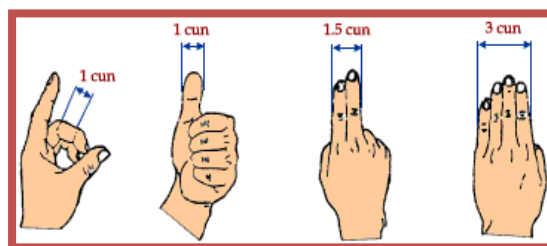
Measurement means the comparison of an unknown quantity with some known quantity.

The **units of measurement** used in ancient times were

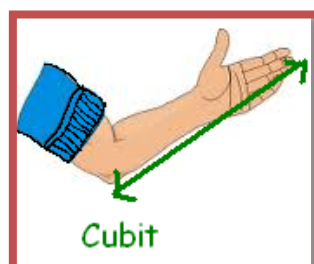
1. Length of the foot



2. Width of the finger



3. Cubit



4. Hand Span



For the sake of uniformity, the **International System of Units (SI units)** was adopted as the most widely used **system of measurement**.

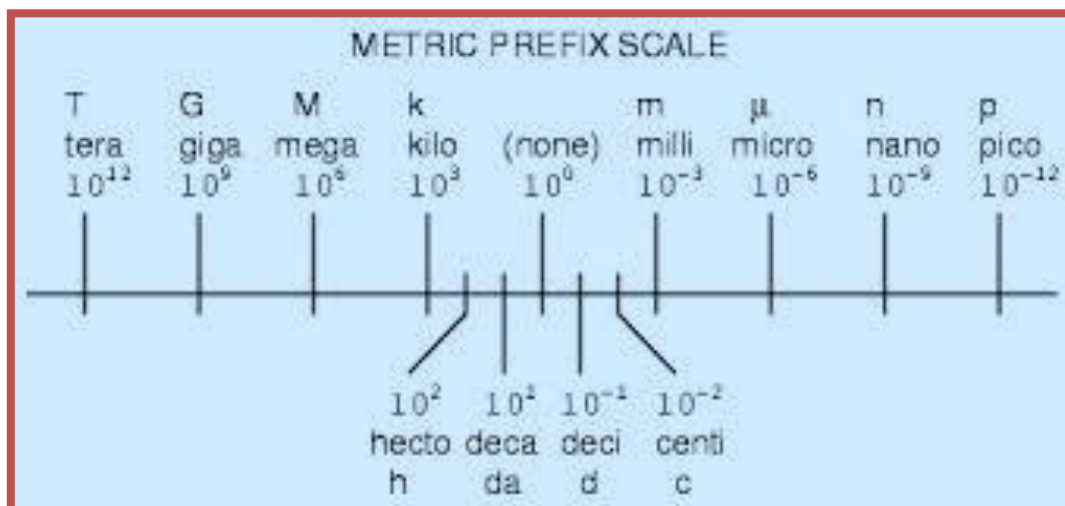
INTERNATIONAL SYSTEM OF UNITS- SI UNIT

Quantities are defined only when they are expressed in numbers and units. Years ago, physicists used either the MKS (meter-kilogram-second) system of units or the CGS (centimetre-gram-second) for length, mass and time. In addition to these three basic quantities are four other: the electric charge or current, temperature, luminous intensity and the amount of substance. Thus, these are seven basic quantities, each has a unit.

The international system of units was adopted by the General Conference on weights and measures in 1960, and the SI units are widely used today.

The SI Base Units		
Quantity	Unit Name	Unit Symbol
Length	meter	m
Time	second	s
Mass	kilogram	kg
Amount of substance	mole	mol
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd

The units which are used to measure large quantities are called **multiple units** and the units which are used to measure smaller quantities are called **sub-multiple units**.



RULES FOR WRITING THE SI UNITS

The following conventions (rules) should be strictly followed while writing SI units.

1) While writing a unit, only its singular form is used. For example, the mass of any substance should be written as kg not kgs. Distances should be expressed in km not in kms, e.g., ten kilogram is written as **10 kg**

2) The abbreviations of any unit does not have full stop (.) at the end, unless it appears at the end of a sentence. Therefore, no full stop is placed either in between or at the end of the symbol of the unit. For example: **kg**

3) One space is left between the last digit of a numeral and the symbol of the unit. For example: **10 m**

4) Words and symbols should not be mixed. For example: **Kilogram per cubic metre is written as kg/m³ and not as kilogram/m³**

5) With numerals, the symbols of the units should be written. For example:

100 cm and not one hundred cm or 100 centimetres

6) The names of the units derived from people's name are written in small letters. For example, the units named after Joule is written as joule (symbol: J). the unit of force named after Newton is written as Newton, (Symbol: N).

7) The sign of degree (°) is not written when the Kelvin scale is employed. For example, temperature of 273 Kelvin is written as,

273 K and not 273°K

MEASUREMENT OF LENGTH

The **SI** unit of **length** is **metre**. The most common measurements are: Millimetre, Centimetre, Metre, and Kilometre.

1 centimetre = 10 millimetre	or	1 cm = 10 mm
1 metre = 100 centimetre	or	1 m = 100 cm
1 metre = 1000 millimetre	or	1 m = 1000 mm
1 kilometre = 1000 metre	or	1 km = 1000 m

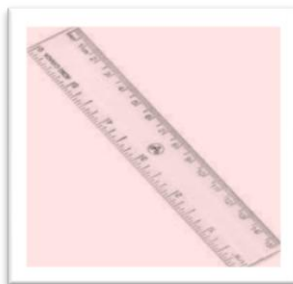
A millimetre is used to measure the thickness of a coin. Centimetre is used to measure the length of a pencil.

Metres might be used to measure the length of a house, or the size of a playground.

The distance from one city to another or how far a plane travels would be measured using kilometres.

DEVICES FOR MEASURING LENGTH

1. The length of a **straight line** is measured by a **metre scale** or **ruler**.



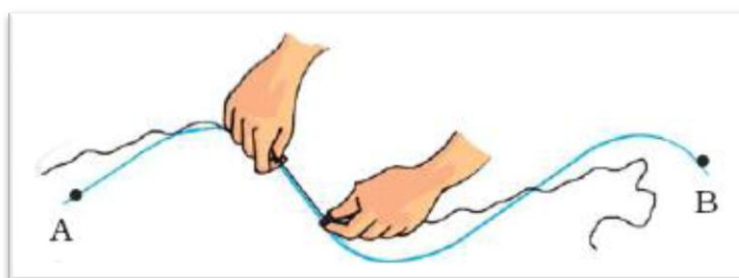
2. Large lengths are measured by the device called **measuring tape**.



3. The round objects are measured by the use of callipers.



4. The **length** of a **curved surface** is measured using a thread.



PROPER USE OF A MEASURING DEVICE

In taking measurement of a length, we need to take care of the following:

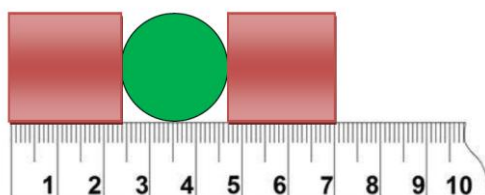
1. Place the scale in contact with the object along its length.
2. In some scales, the ends may be broken. You may not be able to see the zero mark clearly. In such cases, you should avoid taking measurements from the zero mark of the scale.
3. Correct position of the eye is also important for taking measurement. Your eye must be exactly in front of the point where the measurement is to be taken.

INDIRECT METHODS OF MEASUREMENT OF LENGTH

Sometimes, measurements cannot be made directly by using measuring devices. In such cases, we modify the method of measurement.

MEASURING DIAMETER OF A SPHERICAL OBJECT

Diameter of a spherical object like a ball cannot be measured using a ruler. In such cases we use the method described below.



Place a metre scale on a flat table. Place a ball between the two wooden blocks as shown in the figure. The faces of the two blocks touching the ball must be parallel to each other and perpendicular to the scale. Read the metre scale against the inner faces of the two blocks.

Then,

$$\text{Diameter of the ball} = \text{Reading of left face of the block} - \text{Reading of the right face of the Block}$$

In the above figure, if the readings of the blocks are 4.6 cm and 2.4 cm, then

$$\begin{aligned}\text{Diameter of the ball} &= 4.6 \text{ cm} - 2.4 \text{ cm} \\ &= 2.2 \text{ cm}\end{aligned}$$

MEASURING SMALL LENGTH- THICKNESS OF A COIN

It may not be possible to measure the thickness of a coin accurately using a meter scale.

But the exact measurement can be determined by taking a number of coins and placing them one upon the other.

Then,

$$\text{Thickness of a coin} = \text{Thickness of the stack of coins} / \text{No. Of coins in the stack}$$

For example,

$$\text{Number of coins} = 10$$

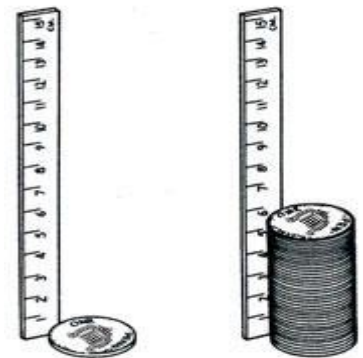
$$\text{Height of the stack} = 6 \text{ cm}$$

$$\text{So thickness of the coin} = 6 \text{ cm} / 10$$

$$= 0.6 \text{ cm}$$

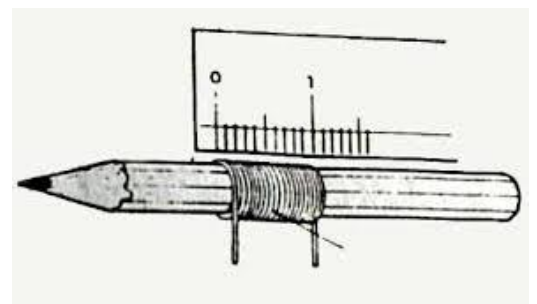
$$= 6 \text{ mm}$$

You can use this method to determine the thickness of a page or a playing card.



MEASURING THE THICKNESS OF A WIRE

A thin wire is spirally wound around a pencil. Each coil of the wire is counted. The coils are then compressed together so they lie compactly on the pencil. The length of the pencil covered with the wire coils is measured on a scale. When this length is divided by the number of coils of



the wire, we get the thickness of the wire.

Thickness of the wire = Total thickness of the coil / No. Of turns of wire in coil

No. Of turns= 10

Total thickness of the coil = 10 mm

Thickness of the wire = $10 \text{ mm} / 10 = 1 \text{ mm}$

MEASURING THE LENGTH OF A CURVED LINE

It is difficult to measure a curve with a ruler with any kind of accuracy, because a metre scale is straight and cannot be bent along the curved line.

The length of the curved line can be measured by using a thread or a divider.

Activity 1

Measuring the length of a curved line using a thread

Materials required:

- A white sheet of paper on which a curved line is drawn.
- A thin and strong cotton thread
- 10 pin
- A centimetre scale
- A drawing board

Method:



Fix the sharp ends of common pins on the curved line.

In figure A, B are the pins fixed on the curved line. Now tie a know with a cotton thread at the common pin A. Using fingers of both hands move the thread along the curved line. Care should be taken that the thread is neither too tight nor too loose, when moved along the curved line. When the thread reaches the extreme end of the curved line, cut it at that point. Remove the thread from A and then place it straight along the length of a centimetre scale. The length of the thread is equal to the length of the curved line.

Activity 2

Measuring the length of a curved line using a divider

Material required:

- Sheet of paper
- Divider
- Centimetre scale

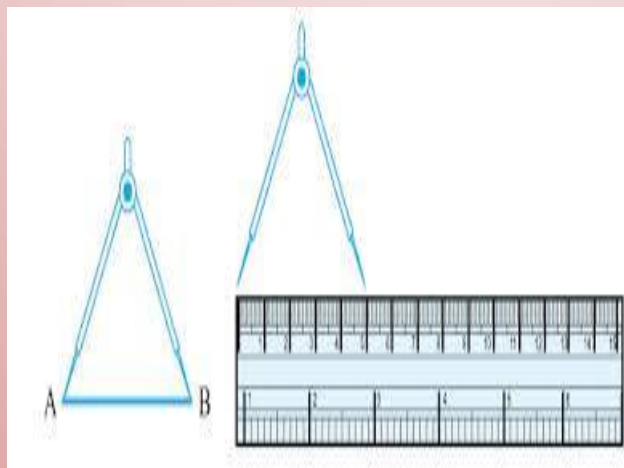
Procedure:

Open the divider so that its legs are a small distance apart, for example 5 mm. Place one of the legs at one end of the line. Take the divider along the line, and count the number of steps in which it covers the entire length of the line. If some portion less than the distance between the two legs is left out, measure it separately by adjusting the distance between the legs.

The length of the curved line is obtained as follows.

Total length = (number of steps x distance between legs of divider) +

Length of left over segment



MEASUREMENT OF AREA

The amount of surface occupied by an object or a place is called its **area**.

The **standard unit** of area is **square metre**. It is written as m^2 . **One square metre is equal to the area of a square each side of which is 1 m in length.**

For measuring bigger areas we use:

$$1 \text{ km}^2 = 1000 \text{ m} \times 1000 \text{ m} = 1000,000 \text{ m}^2$$

$$1 \text{ are} = 10 \text{ m} \times 10 \text{ m} = 100 \text{ m}^2$$

$$1 \text{ hectare} = 100 \text{ m} \times 100 \text{ m} = 10,000 \text{ m}^2$$

Units for smaller areas are the areas of squares with the sides of 1 dm, 1 cm and 1 mm in length. These units are called square decimetre (dm^2), square centimetre (cm^2) and square millimetre (mm^2) respectively.

Relationship between m^2 and cm^2 :

$$1 \text{ m}^2 = 1 \text{ m} \times 1 \text{ m} = 100 \text{ cm} \times 100 \text{ cm} = 10,000 \text{ cm}^2$$

Relationship between cm^2 and mm^2

$$1 \text{ cm}^2 = 1 \text{ cm} \times 1 \text{ cm} = 10 \text{ mm} \times 10 \text{ mm} = 100 \text{ mm}^2$$

MEASURING THE AREA OF A REGULAR SURFACE

All geometric surfaces are called regular surfaces. Area of a regular surface is determined by two methods

1. Geometric method
2. Graphical method

Geometric method:

To measure the areas of regular geometrical figures like a rectangle, a triangle or a circle we have formulas.

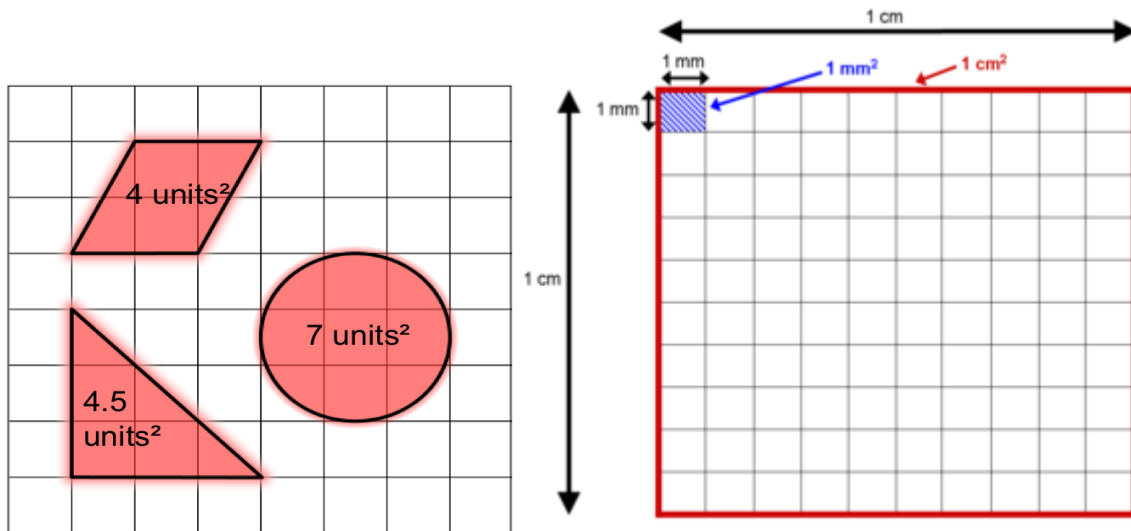
Area of a rectangle = length \times breadth

Area of a triangle = $\frac{1}{2} \text{ base} \times \text{height}$

Area of a circle = $\pi \times (\text{radius})^2$

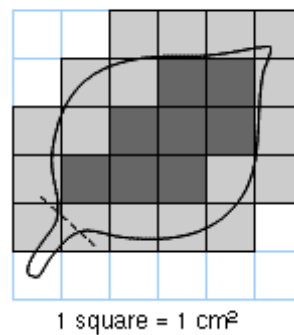
Using these formulae, we can calculate the required area.

Graphical Method: Area of regular surface can be determined using a graph paper or a grid as shown in the figures below



MEASURING AREA OF A IRREGULAR SURFACE

Objects such as a leaf have an irregular shape. The area of such irregular shapes can be determined using a grid as shown in the figures below.



Place the leaf on the grid and draw its outline with a pencil. Count the number of complete squares within the outline. Also count the number of incomplete square.

Total number of squares

$$= \text{number of complete squares} + \text{number of incomplete squares}/2$$

In the above figure, the number of complete squares is 8 and number of incomplete squares is 7.

Total number of squares = $8 + \frac{7}{2}$

$$= 8 + 3.5$$

$$= 11.5$$

Area of one square is 1cm^2 .

Therefore area of the leaf = $11.5 \times 1\text{ cm}^2$

$$= 11.5\text{ cm}^2$$

Mass

Mass is the amount of matter present in a body. We express mass of a body in kilogram (kg), gram (g), quintal, tonne, etc depending upon our requirement. The SI unit of mass is kilogram.

Conversion of commonly used units is as follows:

$$1\text{ tonne} = 10\text{ quintal}$$

$$1\text{ quintal} = 100\text{ kg}$$

$$1\text{ kg} = 1000\text{ g}$$

$$1\text{ g} = 1000\text{ mg}$$

We measure mass using a beam balance and a physical balance. Mass of a body does not vary from place to place.

Beam balance:

A beam balance is normally used by vegetable vendors and in grocery shops.

A beam balance consists of a horizontal beam having a pointer at its centre. Two pans of equal mass are suspended from either sides of the beam. When both the pans are empty, the beam is in the horizontal position. To measure the mass of an object, the object is placed on one of the pans and standard masses are placed on the other pan. The standard masses are adjusted till the beam becomes horizontal. The sum of the standard masses on the pan gives the mass of the object.



Physical balance:

A physical balance is a beam balance that measures the mass of any given object accurately. A physical balance can measure accurately up to a milligram. Physical balances are used by jewellers, in laboratories etc.



Weight:

Weight is the gravitational force that the Earth exerts on any object. The weight of an object gives you an indication of how strongly the Earth attracts that body towards its centre. The SI unit of weight is Newton (N). Since weight is a force it can also be expressed in kilogram force (kg f). Weight is calculated as follows:

$$\text{Weight} = mg$$

Where, m = mass of the object (in kg) and g = the acceleration due to gravity (9.8 m/s^2)

For example, what is Sarah's weight if her mass is 50 kg .Sarah's weight is calculated using the equation as shown below:

$$\begin{aligned}\text{Weight} &= mg \\ &= 50 \text{ kg} \times 9.8 \text{ m/s}^2 \\ &= 490 \text{ kg} \cdot \text{m/s}^2 \\ &= 490 \text{ N}\end{aligned}$$

As weight of a body depends on gravitational force, it varies from one place to another. Weight of a body is measured using a spring balance.

Differences between Mass and Weight

The differences between mass and weight can be summarised in the following table:

Mass	Weight
Amount of matter present in a body	Gravitational force on a body
SI unit is kilogram	SI unit is newton
Measured using beam balance and physical balance	Measured using spring balance
Does not vary with place	It varies with place

Spring balance:

A spring balance is used for measuring the weight of a body.

The principle on which it works is that the extension produced in the spring is directly proportional to the gravitational force acting on it.

A spring balance has a spring fixed with a pointer at the upper part and a hook at the lower end. The spring is enclosed in a metallic case. The pointer moves over a scale attached to the metallic case. When a load is attached to the hook, the spring gets elongated and the pointer moves over the scale. The position of the pointer gives the weight of the body.



MEASUREMENT OF TIME

Our early ancestors used the alternation of the day and night as a clock. They did this because this phenomenon repeats itself at regular intervals of time. As such, they considered this as a standard with which they used to compare an unknown time interval. *Such a system, which repeats itself at regular intervals of time, is called **periodic system**.* The measurement of time is really the comparison of an unknown time interval with the standard time interval of a periodic system. Based on this, instruments like sundials, water and sand clocks were used in early times to measure time intervals. These clocks of early times however, were inconvenient to use because the sundial could not be moved from one place to another place and sand and water clocks had to be attended regularly.

The pendulum was used as a time controller in clocks. In 1656, **Christian Huygens**, a Dutch scientist, made the first pendulum clock, which was regulated by a mechanism using a 'natural' period of oscillation.



Though with the discovery of pendulum clocks, time keeping became almost accurate, but it had certain limitations like acquiring large space, and difficulty in movement from one place to the other. Therefore, spring watches were discovered. Such watches have a flat steel-bound spring, which is coiled tight by winding the spring. As the time passes the spring uncoils moving the hour and minutes hands attached to it. Thus, it tells us the time.

The SI unit of time is second. Bigger units of time are minute (m), hour (h), day (d) etc.

Measuring Time Interval

Time interval by an interval, such as time taken by an athlete to run 100 metre is measured by a special watch. Such a watch is called stop watch. A stop watch can be started and stopped at any moment.



Temperature:

Temperature is the degree of hotness or coldness of a body. The SI unit for temperature is Kelvin. **Thermometer** is the device used to measure temperature.

The extremely fine tube (narrow bore) of a thermometer is called a capillary.

The boiling point of water (or condensing point of steam) is 100°C or 212°F or 373 K .

The freezing point of water (or melting point of ice) is 0°C or 32°F or 273 K .

These temperatures are typically used in the calibration of thermometers and are known as the fixed points.

The temperature range that is typically marked on a laboratory thermometer is -10°C to 110°C .

Thermometric liquids are those that are used in thermometers.

Some examples of such liquids are mercury and alcohol.

The thermometric fluid used by Galileo Galilei in his thermometer was air.

Alcohol, which is used as a thermometric liquid, has the following characteristic properties :

1. Alcohol has a very low freezing point of about -112°C and hence is suitable in thermometers to record very low temperatures.
2. Alcohol has a low boiling point of about 78°C and therefore cannot be used to measure high temperatures.
3. Alcohol can be coloured brightly (by adding a dye, generally red) and then it is clearly visible through glass.
4. Alcohol expands more than mercury.
5. Alcohol is fairly inexpensive.
6. Alcohol wets glass.
7. Alcohol is not a good conductor of heat.

Mercury, which is used as a thermometric liquid, has the following characteristic properties

1. Mercury has a high boiling point of about 357°C and therefore can be used to measure temperatures as high as 357°C .
2. Mercury has a freezing point of about -39°C and hence is suitable in thermometers to record low temperatures (although not very low temperatures).
3. Mercury is opaque and has a shining silvery colour of its own, making it clearly visible in

the capillary tube of a thermometer.

4. Mercury needs very little heat to expand and so it can easily measure the temperature of a body without causing a decrease in the body's temperature.

5. Mercury does not stick to the side of the glass capillary tube of a thermometer.

Therefore, it allows accurate temperature measurement.

6. Mercury is a good conductor of heat.

7. Mercury is relatively expensive.

Clinical Thermometer (or doctor's thermometer) is used for measuring a person's temperature.

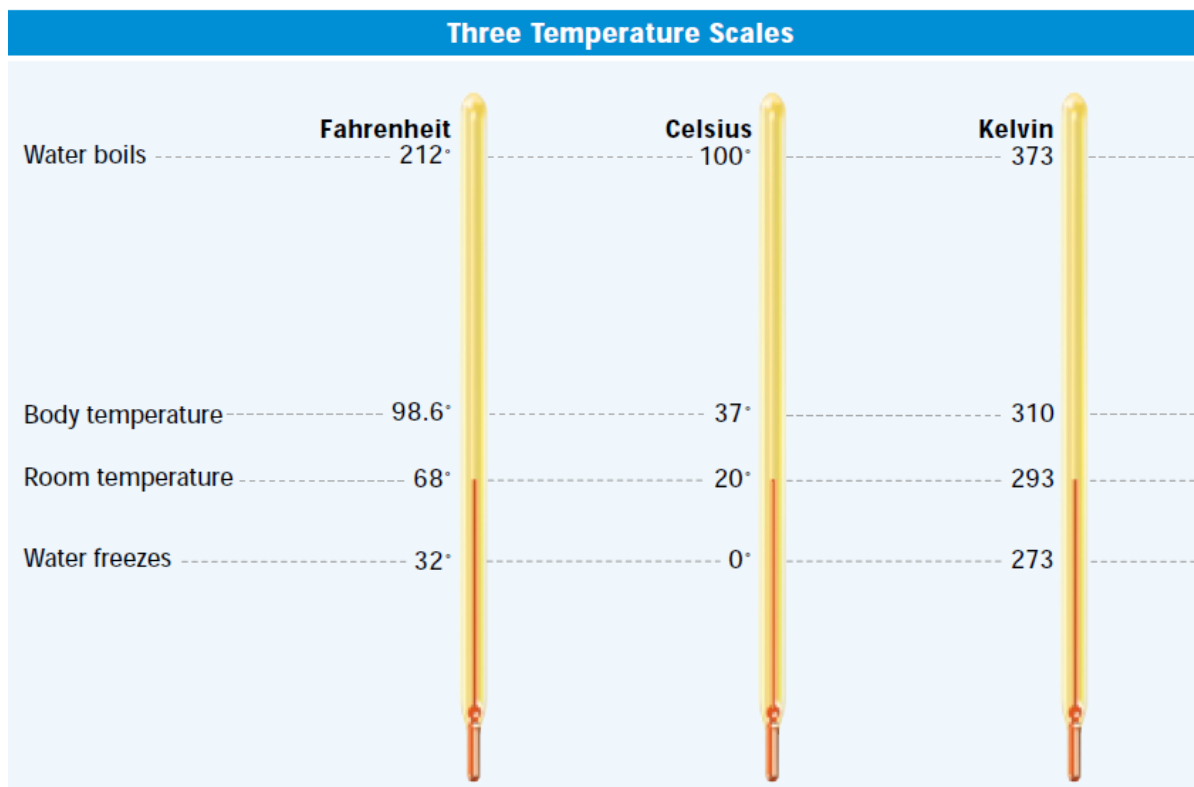
The temperature range that is marked on a clinical thermometer is about 35°C to 43°C (or 95°F to 109°F).

The space above the mercury column in the thermometer is originally vacuum (but may contain some mercury vapor later).

After a clinical thermometer has been used to record a patient's temperature, the mercury is prevented from contracting into the glass bulb by the constriction (kink) unless the thermometer is jerked.

Temperature Scales

Temperature can be expressed using three different scales: Fahrenheit, Celsius, and Kelvin. The SI unit for temperature is the Kelvin (K). Although 0 K is much colder than 0°C , a change of 1 K is equal to a change of 1°C .



Temperature Conversions Table

To convert	Use this equation:	Example
Celsius to Fahrenheit $^{\circ}\text{C} \longrightarrow ^{\circ}\text{F}$	$^{\circ}\text{F} = \left(\frac{9}{5} \times ^{\circ}\text{C}\right) + 32$	Convert 45°C to $^{\circ}\text{F}$. $^{\circ}\text{F} = \left(\frac{9}{5} \times 45^{\circ}\text{C}\right) + 32 = 113^{\circ}\text{F}$
Fahrenheit to Celsius $^{\circ}\text{F} \longrightarrow ^{\circ}\text{C}$	$^{\circ}\text{C} = \frac{5}{9} \times (^{\circ}\text{F} - 32)$	Convert 68°F to $^{\circ}\text{C}$. $^{\circ}\text{C} = \frac{5}{9} \times (68^{\circ}\text{F} - 32) = 20^{\circ}\text{C}$
Celsius to Kelvin $^{\circ}\text{C} \longrightarrow \text{K}$	$\text{K} = ^{\circ}\text{C} + 273$	Convert 45°C to K. $\text{K} = 45^{\circ}\text{C} + 273 = 318 \text{ K}$
Kelvin to Celsius $\text{K} \longrightarrow ^{\circ}\text{C}$	$^{\circ}\text{C} = \text{K} - 273$	Convert 32 K to $^{\circ}\text{C}$. $^{\circ}\text{C} = 32 \text{ K} - 273 = -241^{\circ}\text{C}$