The Metric System











The International System of Units

Origin of the Metric System

- Idea of standardized system of measurement based on the decimal was first proposed <u>as early as ~1670</u>.
- The first practical implementation was carried out by French Revolutionaries towards the end of the 18th century.
- In 1790 a committee (including mathematicians Laplace and Legendre, and chemist Lavoisier) was appointed to develop a unified, natural, universal system of measurement.



It was called the "metric" system (French for measure).

Metrication of the World



Currently USA is the only country (and perhaps also Myanmar and Liberia) **that does not use Metric System...**

Metric System Basics

- The <u>metric system</u> was built around <u>three base units</u> that corresponded to a certain kind of measurement:
 - Length = meter
 - Volume = liter
 - Weight (Mass) = gram
- The base units were derived from the natural world: the *dimensions of the Earth* and *properties of water*.
- <u>Decimal multiplicative prefixes</u> were added to base units to make up the full range of metric system:

Milli + meter = millimeter

Kilo + gram = Kilogram

 Historically, <u>prototypes</u> ("originals") of base units were kept in the Archives Nationales in France with <u>copies manufactured</u> <u>and distributed</u> among other countries - members of The Metre Convention of 1875 (and subsequent conventions).

Fundamental SI Units

As Metric System evolved into the SI system, seven mutually independent fundamental units have been selected:

- 1. Meter (length)
- 2. Kilogram (mass)
- 3. Second (time)
- 4. Kelvin (temperature)
- 5. **Ampere** (electric current)
- 6. **Candela** (luminous intensity)
- 7. **Mole** (amount of elementary entities like atoms or molecules)



The Meter, m (Metric, SI)

- Original definition (1791): <u>one ten millionth</u> (1/10,000,000) <u>of the quarter of the Earth's</u> <u>meridian</u> (distance between the North Pole and the Equator through Paris was determined based on a Pierre Méchain and Jean-Baptiste Delambre 1792-1798 survey of the length of the Earth's meridian between Dunkirk (51°N) and Barcelona (41°N) through Paris).
- 1799: platinum bar, known as the <u>mètre des</u> <u>Archives</u>. The International Metre Commission in Paris (1870-72, 1875): new "metric prototypes" made of 90% platinum and 10% iridium.
- 1983: One meter is the distance traveled by a ray of light through a vacuum in 1/299,792,458 second. The definition in terms of the speed of light means that the meter can be realized using any light source of known frequency, rather than defining a "preferred" source.







The Liter, L (Metric, non-SI)

- Unit of volume, one of three original base units in metric system circa 1799.
- Volume = Length x Width x Height
- The liter is equal to 1 cubic decimeter (10×10×10 centimeters) or 1/1,000 cubic meter.
- One liter of liquid water has a mass of *almost exactly* one kilogram.
- Most commonly used for fluids and solids that can be poured (which are measured by the capacity or size of their container).

 $1L = 1 \text{ dm}^3 = 1000 \text{ cm}^3$



The Gram and the Kilogram, g and kg (Metric, SI)

- Mass: the amount of matter in an object.
- <u>The gram</u>, 1795: the mass of one cubic centimeter of water at the melting point of water.
- The original prototype kilogram manufactured in 1799 had a mass equal to the mass of 1.000025 liters of water at 4°C.
- 1875: <u>The International Prototype Kilogram</u>, a cylinder of platinum/platinum-iridium alloy.
- Kilogram is the only SI unit that is still directly defined by an artifact.
- 2005: International Committee for Weights and Measures recommended that the kilogram <u>be redefined in terms of a</u> fundamental constant of nature.





The Second, s (Metric, SI)

- Earliest documented scientific use of second as a unit of time: ~1000 by Persian scholar al-Biruni.
- Carl Friedrich Gauss, 1832: proposed to use second as a base unit.
- Original definition: 1/86,400 of a mean solar day (the Earth's rotation is slowing down, so in this definition a second was not a constant...)
- International Astronomical Union, 1952-1956 redefinition: the fraction 1/31,556,925.9747 of the tropical year 1900.
- <u>Current definition</u> (developed by General Conference on Weights and Measures in 1967 and refined in 1997): definition using atomic clocks as the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium-133 atom at rest at a temperature of 0 K.
- <u>SI prefixes</u> starting from millisecond are commonly used to measure time <u>less than a second</u> (submultiples); <u>non-SI units</u> *minutes, hours, days, Julian years, Julian centuries,* and *Julian millennia* are used to measure <u>multiples of second</u>.





The Kelvin, K (SI)

- Unit of thermodynamic temperature (absolute temperature).
- Original (1743): the centigrade scale (renamed "Celsius" in 1948) is obtained by assigning 0°C to the freezing point of water and 100°C to the boiling point of water both at a pressure of one standard atmosphere with mercury being the working material.



• Current (1967): 1/273.16 of the thermodynamic temperature of the triple point of water (triple point of water = 273.16 K = 0.01°C by definition).

Prefixes in Metric System

Prefix	Symbol	Factor	
tera	Т	100000000000	10 ¹²
giga	G	100000000	10 ⁹
mega	М	1000000	10 ⁶
kilo	k	1000	10 ³
hecto	h	100	10²
deca	da	10	10 ¹
(none)	(none)	1	10 ⁰
deci	d	0.1	10 ⁻¹
centi	С	0.01	10⁻²
milli	m	0.001	10 ⁻³
micro	μ	0.000001	10 ⁻⁶
nano	n	0.00000001	10 ⁻⁹
pico	р	0.00000000001	10 ⁻¹²

What is the order of the metric system?

- King Henry Died by Drinking Chocolate Milk
- larger

smaller

- King: Kilo
- Henry: Hecto
- Died: Deca
- By: **Base** (m, L, g)
- Drinking: Deci
- Chocolate: Centi
- Milk: Milli

