units

Yair Mau

Table of contents

Home

1 introduction

1.1 dimensions

Dimensions are physical quantities that describe the nature of a measurement, such as length, time, or mass. Units, on the other hand, are standardized quantities used to express the value of a dimension. For example, “meter”, “inch” and “parsec” are units for the dimension of length.

The three fundamental dimensions in mechanics are **length**, **time**, and **mass**. In addition to these, other important dimensions include **temperature**, **electric current**, and **amount of substance**. Each physical quantity can be described in terms of these basic dimensions.

Commonly used dimensions in science and engineering:

Dimension	Symbol	Description	SI Unit
Length	L	distance or size	meter (m)
Time	T	duration or interval	second (s)
Mass	M	amount of matter	kilogram (kg)
Temperature	Θ	degree of hotness	kelvin (K)
Electric current	I	flow of electric charge	ampere (A)
Amount of substance	N	quantity of entities	mole (mol)
Luminous intensity	J	brightness	candela (cd)

1.2 SI

The SI (Système International d’Unités) is the modern form of the metric system and the most widely used system of measurement for science and engineering. It defines seven base units (meter, kilogram, second, ampere, kelvin, mole, and candela) from which all other units are derived. The SI provides a standardized way to express and compare physical quantities across disciplines and countries.

1.3 prefixes

Prefixes are short letter combinations placed before a unit to indicate multiples or fractions of that unit. They make it easier to express very large or very small quantities. The most common prefixes are shown in bold in the table below.

Prefix	Symbol	Power of 10	Common Example
yotta	Y	10^{24}	YB, yottabyte (computing, data)
zetta	Z	10^{21}	ZJ, zettajoule (astronomy, energy)
exa	E	10^{18}	EW, exawatt (energy, power)
peta	P	10^{15}	PB, petabyte (computing, data)**
tera	**T**	10^{12}	**TeV, teraelectronvolt (physics, energy)**
giga	**G**	10^{9}	**GHz, gigahertz (electronics, frequency)**
mega	**M**	10^{6}	**MW, megawatt (energy, power)**
kilo	**k**	10^{3}	**km, kilometer (geography, length)**
hecto	h	10^{2}	hPa, hectopascal (meteorology, pressure)
deca	da	10^{1}	dam, decameter (hydrology, length)
		10^{0}	m, meter (SI, length)
deci	**d**	10^{-1}	**dL, deciliter (chemistry, volume)**
centi	**c**	10^{-2}	**cm, centimeter (biology, length)**
milli	**m**	10^{-3}	**ms, millisecond (neuroscience, time)**
micro	**µ**	10^{-6}	**µm, micrometer (microscopy, length)**
nano	**n**	10^{-9}	**nm, nanometer (materials, length)**
pico	p	10^{-12}	pF, picofarad (electronics, capacitance)
femto	f	10^{-15}	fs, femtosecond (physics, time)
atto	a	10^{-18}	as, attosecond (quantum, time)
zepto	z	10^{-21}	zm, zeptometer (physics, length)
yocto	y	10^{-24}	yg, yoctogram (chemistry, mass)

2 basic concepts

2.1 area and volume

Areas have the dimension of length^2, and volumes have the dimension of length^3.

Attention!
When converting units of area or volume, don't forget to square or cube the prefixes. Huh? Let me give an example.

> how many square meters are in a square kilometer?

$$1\,\mathrm{km}^2 = 1\left(10^3\mathrm{m}\right)^2 = 1\left(10^3\right)^2\left(\mathrm{m}\right)^2 = 10^6\,\mathrm{m}^2$$

There are a million square meters in a square kilometers.

liter

One liter is the volume of a cube of side 10 cm.

> How many liters are in a cubic meter?

$$1\,\mathrm{m}^3 = (100\,\mathrm{cm})^3 = \left(10\cdot 10\,\mathrm{cm}\right)^3 = 10^3\left(10\,\mathrm{cm}\right)^3 = 10^3\,\mathrm{L}$$

There are a thousand liters in a cubic meter.

2.2 concentrations and densities

Concentrations and densities basically answer the question:

> how much of something is there in a given volume?

Let's unpack that.

concentration

Concentrations are very commonly used in chemistry. The quantities can be moles, grams, milligrams, etc. The volumes can be liters, milliliters, etc. A few examples:

- concentration of a given medical compound: 2 μg/mL
- concentration of a reagent: 0.5 mol/L

density

There are several flavors of densities, but usually we mean mass density:

> how much mass is there in a given volume?

For instance, the density of iron is 7.87 g/cm^3

> what is the density of iron in kg/m^3?

$$
\begin{aligned}
&7.87 && \mathrm{g} && \mathrm{cm}^{-3} && (2.1)\\
&7.87 && (10^{-3}10^{3}\,\mathrm{g}) && (10^{-2}\,\mathrm{m})^{-3} && (2.2)\\
&7.87 && (10^{-3}\,\mathrm{kg}) && (10^{-2})^{-3}\,(\mathrm{m})^{-3} && (2.3)\\
&7.87 && 10^{-3}\,\mathrm{kg} && 10^{6}\,\mathrm{m}^{-3} && (2.4)\\
&7.87\cdot 10^{-3}10^{6} && \mathrm{kg} && \mathrm{m}^{-3} && (2.5)\\
&7.87\cdot 10^{3} && \mathrm{kg} && \mathrm{m}^{-3} && (2.6)\\
& && && && (2.7)
\end{aligned}
$$

There are 7870 kg of iron in a cubic meter.

Make sure you are comfortable with what's going on in each of the equations above.