Units and dimensions

Mauro Mongiardo[1]

[1] Department of Engineering, University of Perugia, Perugia, Italy.

Table of contents

Units and dimensions

The measurement of a quantity involves a *unit* and a *number*.

The unit is a reference amount of the quantity, and the number expresses the ratio of the magnitude of that quantity to the magnitude of the unit.

When the unit of a quantity is assigned an arbitrary value, that unit is called a *fundamental unit* and the quantity a *fundamental quantity*.

As an example, in order to measure a distance d we refer to the fundamental quantity of the meter and then express how many meters are in d.

The International System of Units

The International System of Units

The International Systems of Units (SI) is the normalized system currently used in science and engineering for expressing the measurements unit of physical quantities.

The *fundamental quantities* are listed in the Table 1.

All the secondary quantities can be expressed in terms of the fundamental ones.

The importance of Dimensional analysis.

Fundamental and secondary quantities

Fundamental quantities

Table 1: Fundamental quantities of the International System

Dimension	Unit	Symbol
length	metre	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
temperature	kelvin	K
quantity	mole	mol
luminous intensity	candela	cd

Factors

In order to express to quantities between 10^{-18} and 10^{18} the conventional prefixes reported in Table 2 are often used. Note the use of capital letters.

Table 2: Standard prefixes for the SI units of measure

Prefixes	Symbol	Factor
exa	E	10^{18}
peta	P	10^{15}
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}
atto	a	10^{-18}

Vectors and scalars

scalars and vectors

In electromagnetic engineering both scalar and vector quantities are used. We will also extend to other quantities tor describing the three dimensional world. Bivectors, Trivectors, etc.

Scalars are denoted in italic, as an example the resistance is denoted by R (what is the dimension of the resistance? see Resistance dimension.)

Vector quantities are typically denoted in bold; e.g. the electric field is denoted by $\vec{E}$.

When hand writing it is common practice to use the notations $\bar{E}$ or $\underline{\mathrm{E}}$.

Versors, i.e. unit vectors, are denoted either by $\hat{\vec{x}}$ or by adding a subscript $\vec{x}_0$.

As an example an electric field in the x direction can be denoted as $\vec{E} = \vec{x}_0 E$, where E is the module and $\vec{x}_0$ is the versor specifying the direction.

Often, also the notation $\mathbf{u}_x$ may be found for denoting the unit vector in the x direction.

Often the sinusoidal regime is considered and the phasors representation is used.

Note that the time–dependent quantity is different from its phasors representation and therefore, when there is chance of ambiguity, a different symbol should be used in order to distinguish them.

Physical Constants

Physical Constants

Name	Symbol	Value	Unit
Number π	π	3.14159265358979323846	
Number e	e	2.71828182845904523536	
Euler's constant	$\gamma = \lim_{n\to\infty}\left(\sum_{k=1}^{n} 1/k - \ln(n)\right) = 0.5772156649$		
Elementary charge	e	$1.60217733 \cdot 10^{-19}$	C
Gravitational constant	G, κ	$6.67259 \cdot 10^{-11}$	$\mathrm{m^3kg^{-1}s^{-2}}$
Speed of light in vacuum	c	$2.99792458 \cdot 10^{8}$	m/s (def)
Permittivity of the vacuum	ε_0	$8.854187 \cdot 10^{-12}$	F/m
Permeability of the vacuum	μ_0	$4\pi \cdot 10^{-7}$	H/m
Electron mass	m_{e}	$9.1093897 \cdot 10^{-31}$	kg
Proton mass	m_{p}	$1.6726231 \cdot 10^{-27}$	kg
Neutron mass	m_{n}	$1.674954 \cdot 10^{-27}$	kg
Diameter of the Sun	$D_\odot$	$1392 \cdot 10^{6}$	m
Mass of the Sun	$M_\odot$	$1.989 \cdot 10^{30}$	kg
Rotational period of the Sun	$T_\odot$	25.38	days
Radius of Earth	R_{A}	$6.378 \cdot 10^{6}$	m
Mass of Earth	M_{A}	$5.976 \cdot 10^{24}$	kg
Rotational period of Earth	T_{A}	23.96	hours
Earth orbital period	Tropical year	365.24219879	days
Astronomical unit	AU	$1.4959787066 \cdot 10^{11}$	m
Light year	lj	$9.4605 \cdot 10^{15}$	m