Fundamental Dimensions and Base Units

Chapter 7

Table 7-1 Fundamental dimensions and base units

Dimension	Symbol	Unit	Symbol
Length	L	meter	m
Mass	M	kilogram	kg
Time	T	second	s
Temperature	Θ	kelvin	K
Amount of substance	N	mole	mol
Light intensity	J	candela	cd
Electric current	I	ampere	A

Scientific vs Engineering Notation

Scientific notation is typically expressed in the form #.### × 10^N, where the digit to the left of the decimal point is the most significant nonzero digit of the value being represented. Sometimes, the digit to the right of the decimal point is the most significant digit instead. The number of decimal places can vary, but is usually two to four. N is an integer, and multiplying by 10^N serves to locate the true position of the decimal point.

Engineering notation is expressed in the form ###.### × 10^M, where M is an integer multiple of 3, and the number of digits to the left of the decimal point is 1, 2, or 3 as needed to yield a power of 10 that is indeed a multiple of 3. The number of digits to the right of the decimal point is typically between two and four.

Table 7-2 SI prefixes (example: 1 millimeter [mm] = 1 × 10^{-3} meters [m])

Numbers Less than One			Numbers Greater than One		
Power of 10	Prefix	Abbreviation	Power of 10	Prefix	Abbreviation
10^{-1}	deci-	d	10^{1}	deca-	da
10^{-2}	centi-	c	10^{2}	hecto-	h
10^{-3}	milli-	m	10^{3}	kilo-	k
10^{-6}	micro-	μ	10^{6}	Mega-	M
10^{-9}	nano-	n	10^{9}	Giga-	G
10^{-12}	pico-	p	10^{12}	Tera-	T
10^{-15}	femto-	f	10^{15}	Peta-	P
10^{-18}	atto-	a	10^{18}	Exa-	E
10^{-21}	zepto-	z	10^{21}	Zetta-	Z
10^{-24}	yocto-	y	10^{24}	Yotta-	Y

EXAMPLE 7-1 Express the following values using scientific notation, engineering notation, and using the correct SI prefix.

Standard	Scientific	Engineering	With Prefix
(a) 43,480,000 m	4.348×10^{7} m	43.48×10^{6} m	43.48 Mm
(b) 0.0000003060 V	3.060×10^{-7} V	306.0×10^{-9} V	306.0 nV
(c) 9,860,000,000 J	9.86×10^{9} J	9.86×10^{9} J	9.86 GJ
(d) 0.0351 s	3.51×10^{-2} s	35.1×10^{-3} s	35.1 ms

Note that the numeric values of the mantissa are the same in the last two columns, and the exponent in engineering notation specifies the metric prefix.

COMPREHENSION CHECK 7–1 Express the following values using scientific notation, engineering notation, and using the correct SI prefix.

Standard	Scientific	Engineering	With Prefix
(a) 3,100 J			
(b) 26,510,000 W			
(c) 459,000 s			
(d) 0.00000032 g			

Official SI Rules

- Page 160
- Upper Case –named after someone
- Exception is L or I – lower case could be confusing
- Plural units – no “s”
- Space between Value and Unit
- Three groups of zeros – 000,000,000

Other Unit Systems

Table 7-3 Comparison of unit system, with corresponding abbreviations

Dimension	SI (MKS)	AES	USCS
Length {L}	meter [m]	foot [ft]	foot [ft]
Mass {M}	kilogram [kg]	pound-mass [lb_m]	slug
Time {T}	second [s]	second [s]	second [s]
Relative temperature {Θ}	Celsius [°C]	Fahrenheit [°F]	Fahrenheit [°F]
Absolute temperature {Θ}	kelvin [K]	Rankine [°R]	Rankine [°R]

Accepted Non-SI Units

The units in Table 7-4 are not technically in the SI system, but due to their common usage, are acceptable for use in combination with the base SI units.

Table 7-4 Acceptable non-SI units

Unit	Equivalent SI	Unit	Equivalent SI
Astronomical unit [AU]	1 AU = 1.4959787×10^{11} m	day [d]	1 d = 86,400 s
Atomic mass unit [amu]	1 amu = $1.6605402 \times 10^{-24}$ g	hour [h]	1 h = 3,600 s
Electronvolt [eV]	1 eV = $1.6021773 \times 10^{-19}$ J	minute [min]	1 min = 60 s
Liter [L]	1 L = 0.001 m^3	year [yr]	1 yr = 3.16×10^7 s
		degree [°]	1° = 0.0175 rad or 1 rad = 57.3°

Conversion Procedure

Unit Conversion Procedure

1. Write the value and unit to be converted.
2. Write the conversion formula between the given unit and the desired unit.
3. Make a fraction, equal to 1, of the conversion formula in Step 2, such that the original unit in Step 1 is located either in the denominator or in the numerator, depending on where it must reside so that the original unit will cancel.
4. Multiply the term from Step 1 by the fraction developed in Step 3.
5. Cancel units, perform mathematical calculations, and express the answer in "reasonable" terms (i.e., not too many decimal places).

Examples

EXAMPLE 7-2 Convert the length 40 yards [yd] into units of feet [ft].

Method	Steps
(1) Term to be converted	40 yd
(2) Conversion formula	1 yd = 3 ft
(3) Make a fraction (equal to one)	$\frac{3\text{ ft}}{1\text{ yd}}$
(4) Multiply	$\frac{40\text{ yd}}{}\left\vert\frac{3\text{ ft}}{1\text{ yd}}\right.$
(5) Cancel, calculate, be reasonable	120 ft

EXAMPLE 7-3 Convert the time 456,200 seconds [s] into units of minutes [min].

Method	Steps
(1) Term to be converted	456,000 s
(2) Conversion formula	1 min = 60 s
(3) Make a fraction (equal to one)	$\frac{1\text{ min}}{60\text{ s}}$
(4) Multiply	$\frac{456{,}000\text{ s}}{}\left\vert\frac{1\text{ min}}{60\text{ s}}\right.$
(5) Cancel, calculate, be reasonable	7,600 min

Table 7-5 Common derived units in the SI system

Dimension	SI Unit	Base SI Units	Derived from
Force (*F*)	newton [N]	$1\text{ N} = 1\frac{\text{kg m}}{\text{s}^2}$	$F = ma$ Force = mass times acceleration
Energy (*E*)	joule [J]	$1\text{ J} = 1\text{ N m} = 1\frac{\text{kg m}^2}{\text{s}^2}$	$E = Fd$ Energy = force times distance
Power (*P*)	watt [W]	$1\text{ W} = 1\frac{\text{J}}{\text{s}} = 1\frac{\text{kg m}^2}{\text{s}^3}$	$P = E/t$ Power = energy per time
Pressure (*P*)	pascal [Pa]	$1\text{ Pa} = 1\frac{\text{N}}{\text{m}^2} = 1\frac{\text{kg}}{\text{m s}^2}$	$P = F/A$ Pressure = force per area
Voltage (*V*)	volt [V]	$1\text{ V} = 1\frac{\text{W}}{\text{A}} = 1\frac{\text{kg m}^2}{\text{s}^3\text{ A}}$	$V = P/I$ Voltage = power per current

- A note of caution: One letter can represent several quantities in various engineering disciplines. For example, the letter "*P*" can indicate pressure, power, or vertical load