

### Natural Constants

Name	Symbol	Value	Unit	Relative Uncertainty
speed of light in vacuum	<i>c</i>	299 792 458	m · s <sup>-1</sup>	exact
magnetic constant	<i>μ</i> <sub>0</sub>	4π · 10 <sup>-7</sup> = 12.566 370 614 ... · 10 <sup>-7</sup>	N · A <sup>-2</sup>	exact
electric constant	<i>ε</i> <sub>0</sub>	8.854 187 817 ... · 10 <sup>-12</sup>	F · m <sup>-1</sup>	exact
Newtonian constant of gravitation	<i>G</i>	6.674 28 (67) · 10 <sup>-11</sup>	m <sup>3</sup> · kg <sup>-1</sup> · s <sup>-2</sup>	1.0 · 10 <sup>-4</sup>
Planck constant	<i>h</i>	6.626 068 96 (33) · 10 <sup>-34</sup>	J · s	5.0 · 10 <sup>-8</sup>
elementary charge	<i>e</i>	1.602 176 487 (40) · 10 <sup>-19</sup>	C	2.5 · 10 <sup>-8</sup>
magnetic flux quantum	<i>Φ</i> <sub>0</sub>	2.067 833 667 (52) · 10 <sup>-15</sup>	Wb	2.5 · 10 <sup>-8</sup>
conductance quantum	<i>G</i> <sub>0</sub>	7.748 091 700 4 (53) · 10 <sup>-5</sup>	S	6.8 · 10 <sup>-10</sup>
electron mass	<i>m</i> <sub>e</sub>	9.109 382 15 (45) · 10 <sup>-31</sup>	kg	5.0 · 10 <sup>-8</sup>
proton mass	<i>m</i> <sub>p</sub>	1.672 621 637 (83) · 10 <sup>-27</sup>	kg	5.0 · 10 <sup>-8</sup>
atomic mass unit	<i>m</i> <sub>u</sub>	1.660 538 782 (83) · 10 <sup>-27</sup>	kg	5.0 · 10 <sup>-8</sup>
fine-structure constant	<i>α</i>	7.297 352 537 6 (50) · 10 <sup>-3</sup>		6.8 · 10 <sup>-10</sup>
Rydberg constant	<i>R</i> <sub>∞</sub>	10 973 731.568 527 (73)	m <sup>-1</sup>	6.6 · 10 <sup>-12</sup>
Avogadro constant	<i>N</i> <sub>A</sub>	6.022 141 79 (30) · 10 <sup>23</sup>	mol <sup>-1</sup>	5.0 · 10 <sup>-8</sup>
Faraday constant	<i>F</i>	96 485.339 9 (24)	C · mol <sup>-1</sup>	2.5 · 10 <sup>-8</sup>
molar gas constant	<i>R</i>	8.314 472 (15)	J · mol <sup>-1</sup> · K <sup>-1</sup>	1.7 · 10 <sup>-6</sup>
Boltzmann constant	<i>k</i>	1.380 650 4 (24) · 10 <sup>-23</sup>	J · K <sup>-1</sup>	1.7 · 10 <sup>-6</sup>

In accordance with the *Committee on Data for Science and Technology (CODATA 2006)*. [www.codata.org/taskgroups/TGfundconst](http://www.codata.org/taskgroups/TGfundconst). Number in parentheses: numerical value of the standard uncertainty referred to the last two figures of the quoted value.

### Correct Writing of Numerical Values of Physical Quantities

#### Example

Generally  $A = \{A\} \cdot [A]$

$A$ : physical quantity,  $\{A\}$ : numerical value,  $[A]$ : unit .....  $\lambda = 3.896 \cdot 10^{-7}$  m or  $\lambda = 389.6$  nm

Under ISO 31-0, the decimal marker is indicated by a comma ..... (3,896)

In English and in the computer field a dot on the line (expressed as «point»)

is more commonly used ..... 3.896

For the sake of greater readability, in technical and scientific fields four or more digit numbers are expressed in groups of three digits..... 4 867.219 1 instead of 4867.2191

To clarify multiplication, a dot (mid-level) or an x (cross) is used ..... 3.86 · 4.23 or 3.86 × 4.23

Subscripts for quantities should be used with the quantity symbol, not the unit symbol.....  $U_{\max} = 500$  V not  $U = 500$  V<sub>max</sub>

A symbol for a physical quantity is printed in italic type, units and functions are printed in roman (upright) type.....  $p(h) = p_0 \exp(-h/8000$  m)

### D SI Prefixes • Decimal Multiples and Sub-Multiples

#### SI Prefixes

Factor	Name	Symbol
1 000 000 000 000 000 000 000 000 = 10 <sup>24</sup>	yotta	Y
1 000 000 000 000 000 000 000 000 = 10 <sup>21</sup>	zetta	Z
1 000 000 000 000 000 000 000 000 = 10 <sup>18</sup>	exa	E
1 000 000 000 000 000 000 000 000 = 10 <sup>15</sup>	peta	P
1 000 000 000 000 000 000 000 000 = 10 <sup>12</sup>	tera	T
1 000 000 000 000 000 000 000 000 = 10 <sup>9</sup>	giga	G
1 000 000 000 000 000 000 000 000 = 10 <sup>6</sup>	mega	M
1 000 000 000 000 000 000 000 000 = 10 <sup>3</sup>	kilo	k
100 000 000 000 000 000 000 000 = 10 <sup>2</sup>	hecto	h
10 000 000 000 000 000 000 000 = 10 <sup>1</sup>	deca	da
0,1 000 000 000 000 000 000 000 = 10 <sup>-1</sup>	deci	d
0,01 000 000 000 000 000 000 000 = 10 <sup>-2</sup>	centi	c
0,001 000 000 000 000 000 000 000 = 10 <sup>-3</sup>	milli	m
0,000 001 000 000 000 000 000 000 = 10 <sup>-6</sup>	micro	μ
0,000 000 001 000 000 000 000 000 = 10 <sup>-9</sup>	nano	n
0,000 000 000 001 000 000 000 000 = 10 <sup>-12</sup>	pico	p
0,000 000 000 000 001 000 000 000 = 10 <sup>-15</sup>	femto	f
0,000 000 000 000 000 001 000 000 = 10 <sup>-18</sup>	atto	a
0,000 000 000 000 000 000 001 000 = 10 <sup>-21</sup>	zepto	z
0,000 000 000 000 000 000 000 001 = 10 <sup>-24</sup>	yocto	y

#### Decimal Multiples and Sub-Multiples

Since numbers of more than 1 000 and less than 0.01 require a lot of space and make reading difficult, under the SI system special prefixes for decimal multiples and sub-multiples are used. These are written without spaces immediately in front of the units. The accumulation of prefixes is not allowed. In this case, exponentials always refer to the entire prefixed unit. The sub-multiple and multiple of the kilogram base unit are represented by «gram» respectively by «ton» for 1 000 kilograms. The SI prefixes do not apply to angle units °, ' and ′, the time units min, h and d, the surface area units a and ha, the metric carat ct, the dioptré and the millimetre of mercury.

#### Example

12 000 N = 12 · 10<sup>3</sup> N = 12 kN  
 0,000 05 s = 50 · 10<sup>-6</sup> s = 50 μs  
 0,004 μm = 4 · 10<sup>-3</sup> μm = 4 · 10<sup>-9</sup> m = 4 nm  
 0,000 004 kg = 4 · 10<sup>-6</sup> kg = 4 · 10<sup>-3</sup> g = 4 mg  
 6 · 10<sup>9</sup> kg = 6 · 10<sup>6</sup> t = 6 Mt  
 7 000 min = 116,7 h = 4,86 d

### E Conversion into SI Units of Non Metric Units (US resp. UK Units)

Quantity	Unit	Abbreviation	Conversion
<b>Length</b>	inch	in	1 in = 25.4 mm
	foot	ft	1 ft = 12 in = 0.304 8 m
	yard	yd	1 yd = 3 ft = 0.914 4 m
	mile (statute)	mi	1 mi = 1 760 yd = 1.609 344 km
	nautical mile (int.)	nmi	1 nmi = 1.852 km
<b>Velocity</b>	knot (international)	kn	1 kn = 1 nmi · h <sup>-1</sup> = 0.514 44 ... m · s <sup>-1</sup>
	mile per hour	mi · h <sup>-1</sup> , mph	1 mi · h <sup>-1</sup> = 0.447 04 m · s <sup>-1</sup>
<b>Area</b>	square inch	sq in	1 sq in = 6.451 6 cm <sup>2</sup>
	square foot	sq ft	1 sq ft = 144 sq in = 929.030 4 cm <sup>2</sup>
	square yard	sq yd	1 sq yd = 9 sq ft = 0.836 127 36 m <sup>2</sup>
	rood		1 rood = 1 210 sq yd = 1 011.71 ... m <sup>2</sup>
	acre		1 acre = 4 roods = 4 046.86 ... m <sup>2</sup>
square mile	sq mi	1 sq mi = 640 acres = 2.589 988 ... km <sup>2</sup>	
<b>Volume</b>	cubic inch	cu in	1 cu in = 16.387 064 cm <sup>3</sup>
	cubic foot	cu ft	1 cu ft = 28.316 8 ... dm <sup>3</sup>
	cubic yard	cu yd	1 cu yd = 0.764 555 ... m <sup>3</sup>
<b>British measures of capacity</b>	UK fluid ounce	UK fl oz	1 fl oz = 28.413 062 5 cm <sup>3</sup>
	UK gill		1 gill = 5 fl oz = 0.142 065 ... dm <sup>3</sup>
	UK pint	UK pt	1 pt = 20 fl oz = 0.568 261 ... dm <sup>3</sup>
	UK quart	UK qt	1 qt = 2 pt = 1.136 522 5 dm <sup>3</sup>
	UK gallon	UK gal	1 gal = 4 qt = 4.546 09 dm <sup>3</sup>
<b>American fluid measures</b>	US fluid ounce	US fl oz	1 fl oz = 29.573 5 ... cm <sup>3</sup>
	US gill	gi	1 gi = 4 fl oz = 0.118 294 ... dm <sup>3</sup>
	US liquid pint	liq pt	1 liq pt = 4 gi = 0.473 176 ... dm <sup>3</sup>
	US liquid quart	liq qt	1 liq qt = 2 liq pt = 0.946 353 ... dm <sup>3</sup>
	US gallon	US gal	1 gal = 4 liq qt = 3.785 41 ... dm <sup>3</sup>
	US barrel (oil)	bbl	1 bbl = 42 gal = 158.987 ... dm <sup>3</sup>

Quantity	Unit	Abbreviation	Conversion
<b>American dry measures</b>	US dry pint	dry pt	1 dry pt = 0.550 610 ... dm <sup>3</sup>
	US dry quart	dry qt	1 dry qt = 2 dry pt = 1.101 2 ... dm <sup>3</sup>
	US peck	pk	1 pk = 8 dry qt = 8.809 76 ... dm <sup>3</sup>
	US bushel	bu	1 bu = 4 pk = 35.239 1 ... dm <sup>3</sup>
<b>Mass</b>	grain	gr	1 gr = 0.064 798 91 g
	dram (avoirdupois)	dr	1 dr = 27.343 75 gr = 1.771 85 ... g
	ounce (avoirdupois)	oz	1 oz = 16 dr = 28.349 5 ... g
	troy ounce	oz tr	1 oz tr = 480 gr = 31.103 476 8 g
	pound (avoirdupois)	lb	1 lb = 16 oz = 0.453 592 37 kg
	troy pound	lb tr	1 lb tr = 12 oz tr = 0.373 242 ... kg
	stone (UK)		1 stone = 14 lb = 6.350 293 18 kg
	(long) ton (UK)	ton	1 ton = 2 240 lb = 1 016.05 ... kg
	short ton (US)	sh ton	1 sh ton = 2 000 lb = 907.184 74 kg
	<b>Force</b>	poundal	pdl
pound-force		lbf	1 lbf = 4.448 22 ... N
UK ton-force		UK tonf	1 UK tonf = 2 240 lbf = 9 964.02 ... N
US ton-force = 2 kip		US tonf	1 US tonf = 2 000 lbf = 8 896.44 ... N
<b>Pressure</b>	pound-force/sq ft	lbf · ft <sup>-2</sup>	1 lbf · ft <sup>-2</sup> = 47.880 3 ... Pa
	pound-force/sq in	lbf · in <sup>-2</sup> , psi	1 lbf · in <sup>-2</sup> = 6.894 76 ... kPa
<b>Energy, thermal energy</b>	foot pound-force	ft · lbf	1 ft · lbf = 1.355 82 ... J
	British thermal unit	Btu <sub>IT</sub>	1 Btu <sub>IT</sub> = 1.055 06 ... kJ
<b>Power</b>	therm		1 therm = 10 <sup>5</sup> Btu = 105.506 ... MJ
	British thermal unit/hour	Btu/h	1 Btu/h = 0.293 071 ... W
<b>Temperature</b>	horsepower	hp	1 hp = 550 ft · lbf/s = 745.700 ... W
	degree Fahrenheit	°F	Temp. /°C = (Temp. /°F - 32) · 5/9 Temperature Diff. 1 °F = 5/9 °C = 5/9 K
<b>Illuminance</b>	foot Lambert	fL	1 fL = π <sup>-1</sup> cd · ft <sup>-2</sup> = 3.426 4 ... cd · m <sup>-2</sup>
<b>Illuminance</b>	foot candle	fc	1 fc = 1 lm · ft <sup>-2</sup> = 10.763 4 ... lx

Further UK and US units: [http://en.wikipedia.org/wiki/conversion\\_of\\_units](http://en.wikipedia.org/wiki/conversion_of_units)