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UNITS OF MEASUREMENT

The International System of Units, established in 1960 by the 11th General Conference on Weights and Measures (CGPM), is the modern metric system of measurement used throughout the world. It is universally abbreviated SI (from the French *Le Système International d'Unités*). The editor of this updated version of the *ISA Handbook of Measurement Equations and Tables* credits the National Institute of Standards and Technology (NIST) Special Publications 811, *Guide for the Use of the International System of Units* (SI), and Special Publications 330, *The International System of Units*, for several of the useful tables presented in this chapter.

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Greek Alphabet in Roman and Italic Type				
Name	Capital Roman	Lower Case Roman	Capital Italic	Lower Case Italic
alpha	Α	α	*Α*	*α*
beta	Β	β	*Β*	*β*
gamma	Γ	γ	*Γ*	*γ*
delta	Δ	δ	*Δ*	*δ*
epsilon	Ε	ε,∈	*Ε*	*ε,∈*
zeta	Ζ	ζ	*Ζ*	*ζ*
eta	Η	η	*Η*	*η*
theta	Θ,θ	Θ,θ	*Θ,θ*	*Θ,θ*
iota	Ι	ι	*Ι*	*ι*
kappa	Κ	κ	*Κ*	*κ*
lambda	Λ	λ	*Λ*	*λ*
mu	Μ	μ	*Μ*	*μ*
nu	Ν	ν	*Ν*	*ν*
xi	Ξ	ξ	*Ξ*	*ξ*
omicron	Ο	ο	*Ο*	*ο*
pi	Π	π, ϖ	*Π*	*π, ϖ*
rho	Ρ	ρ	*Ρ*	*ρ*
sigma	Σ	σ	*Σ*	*σ*
tau	Τ	τ	*Τ*	*τ*
upsilon	Υ	υ	*Υ*	*υ*
phi	Φ	φ, ϕ	*Φ*	*φ, ϕ*
chi	Χ	χ	*Χ*	*χ*
psi	Ψ	ψ	*Ψ*	*ψ*
omega	Ω	ω	*Ω*	*ω*

The Three Classes of SI Units and the SI Prefixes

SI units are currently divided into three classes:

- Base units
- Derived units
- Supplementary units

Together, the three classes form what is called "the coherent system of SI units."

SI base units

The following table gives the seven base quantities, assumed to be mutually independent, on which the SI is founded, and the names and symbols of their respective units, called "SI base units." Definitions of the SI base units follow. The kelvin and its symbol K are also used to express the value of a temperature interval or a temperature difference.

SI Base Units		
Base Quantity	**Name**	**Symbol**
length	meter	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd

Definitions of SI Base Units

Meter (17th CGPM, 1983)
The meter is the length of the path traveled by light in vacuum during a time interval of 1/299,792,458 of a second.

Kilogram (3d CGPM, 1901)
The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram.

Second (13th CGPM, 1967)
The second is 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 cesium-133 atom.

Ampere (9th CGPM, 1948)
The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross section, and placed 1 meter apart in vacuum, would produce between these conductors a force equal to 2×10^{-7} *Newton per meter of length.*

Kelvin (13th CGPM, 1967)
The kelvin, unit of thermodynamic temperature, is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water.

Mole (14th CGPM, 1971)

1. *The mole is the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon 12.*
2. *When the mole is used, the elementary entities must be specified and may be atoms, molecules, ions, electrons, other particles, or specified groups of such particles.*

In the definition of the mole, it is understood that unbound atoms of carbon 12, at rest and in their ground state, are referred to.

Note that this definition specifies at the same time the nature of the quantity whose unit is the mole.

Candela (16th CGPM, 1979)
The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540 x 1012 hertz and that has a radiant intensity in that direction of (1/683) watt per steradian.

SI Derived Units

Derived units are expressed algebraically in terms of base units or other derived units, including the radian and steradian, which are two supplementary units. The radian is defined as the plane angle between two radii of a circle that cut off on the circumference an arc equal in length to the radius. The steradian is fined as the solid angle that, having its vertex in the center of a sphere, cuts off an area of the surface of the sphere equal to that of a square with sides of length equal to the radius of the sphere.

SI Derived Units		
Quantity	**SI Unit**	**SI Symbol**
Frequency	Hertz	Hz
Force	Newton	N
Pressure, Stress	Pascal	Pa
Energy, Work, Heat	Joule	J
Power, Radiant Flux	Watt	W
Electric Charge	Coulomb	C
Electric Potential, Force	Volt	V
Electric Resistance	Ohm	Ω
Electric Conductance	Siemens	S
Electric Capacitance	Farad	F
Magnetic Flux Density	Tesla	T
Magnetic Flux	Weber	Wb
Inductance	Henry	H
Temperature	°Celsius	°C
Luminous Flux	Lumen	lm
Illuminance	Lux	lx
Radioactive Activity	Becquerel	Bq
Absorbed Dose	Gray	Gy
Dose Equivalent	Sievert	Sv
Plane Angle	Radian	rad
Solid Angle	Steradian	sr

The symbols for derived units are obtained by means of the mathematical operations of multiplication and division. For example, the derived unit for the derived quantity molar mass (mass divided by amount of substance) is the kilogram per mole, symbol kg/mol. Additional examples of derived units expressed in terms of SI base units are given in the following table.

Examples of SI Derived Units Expressed in Terms of SI Base Units

Derived Quantity	Name	Symbol
area	square meter	m^2
volume	cubic meter	m^3
speed, velocity	meter per second	m/s
acceleration	meter per second squared	m/s^2
wave number	reciprocal meter	m^{-1}
mass density (density)	kilogram per cubic meter	kg/m^3
specific volume	cubic meter per kilogram	m^3/kg
current density	ampere per square meter	A/m^2
magnetic field strength	ampere per meter	A/m
amount-of-substance concentration (concentration)	mole per cubic meter	mol/m^3
luminance	candela per square meter	cd/m^2