A1

The International System of Units, Fundamental Constants, and Conversion Factors

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The International system of units (SI) is based on seven base units. Other derived units can be related to these base units through governing equations. The base units with the recommended symbols are listed in Table A1.1. Derived units of interest in solar engineering are given in Table A1.2.

Standard prefixes can be used in the SI system to designate multiples of the basic units and thereby conserve space. The standard prefixes are listed in Table A1.3.

Table A1.4 lists some physical constants that are frequently used in solar engineering, together with their values in the SI system of units.

Conversion factors between the SI and English systems for commonly used quantities are given in Table A1.5.

TABLE A1.1 The Seven SI Base Units

Quantity	Name of Unit	Symbol
Length	Meter	m
Mass	Kilogram	kg
Time	Second	s
Electric current	Ampere	A
Thermodynamic temperature	Kelvin	K
Luminous intensity	Candela	cd
Amount of a substance	Mole	mol

TABLE A1.2 SI Derived Units

Quantity	Name of Unit	Symbol
Acceleration	Meters per second squared	m/s^2
Area	Square meters	m^2
Density	Kilogram per cubic meter	kg/m^3
Dynamic viscosity	Newton-second per square meter	$N\ s/m^2$
Force	Newton ($=1$ kg m/s^2)	N
Frequency	Hertz	Hz
Kinematic viscosity	Square meter per second	m^2/s
Plane angle	Radian	rad
Potential difference	Volt	V
Power	Watt($=1$ J/s)	W
Pressure	Pascal ($=1$ N/m^2)	Pa
Radiant intensity	Watts per steradian	W/sr
Solid angle	Steradian	sr
Specific heat	Joules per kilogram–Kelvin	J/kg K
Thermal conductivity	Watts per meter–Kelvin	W/m K
Velocity	Meters per second	m/s
Volume	Cubic meter	m^3
Work, energy, heat	Joule ($=1$ N/m)	J

TABLE A1.3 English Prefixes

Multiplier	Symbol	Prefix	Multiplier	Multiplier Symbol
10^{12}	T	Tera	10^3	M (thousand)
10^9	G	Giga	10^6	MM (million)
10^6	m	Mega		
10^3	k	Kilo		
10^2	h	Hecto		
10^1	da	Deka		
10^{-1}	d	Deci		
10^{-2}	c	Centi		
10^{-3}	m	Milli		
10^{-6}	μ	Micro		
10^{-9}	n	Nano		
10^{-12}	p	Pico		
10^{-15}	f	Femto		
10^{-18}	a	Atto		

TABLE A1.4 Physical Constants in SI Units

Quantity	Symbol	Value
Avogadro constant	N	6.022169×10^{26} kmol^{-1}
Boltzmann constant	k	1.380622×10^{-23} J/K
First radiation constant	$C_1 = 2\pi h C^2$	3.741844×10^{-16} W m^2
Gas constant	R	8.31434×10^{3} J/kmol K
Planck constant	h	6.626196×10^{-34} J s
Second radiation constant	$C_2 = hc/k$	1.438833×10^{-2} m K
Speed of light in a vacuum	C	2.997925×10^{8} m/s
Stefan–Boltzmann constant	σ	5.66961×10^{-8} W/m^2 K^4

TABLE A1.5 Conversion Factors

Physical Quantity	Symbol	Conversion Factor
Area	A	1 ft.^{2} = 0.0929 m^2
		1 acre = 43,560 ft.^{2} = 4047 m^2
		1 hectare = 10,000 m^2
		1 square mile = 640 acres
Density	ρ	1 lb$_m$/ft.^{3} = 16.018 kg/m^3
Heat, energy, or work	Q or W	l Btu = 1055.1 J
		1 kWh = 3.6 MJ
		1 Therm = 105.506 MJ
		l cal = 4.186 J
		1 ft. lb$_f$ = 1.3558 J
Force	F	1 lb$_f$ = 4.448 N
Heat flow rate, refrigeration	q	1 Btu/h = 0.2931 W
		1 ton (refrigeration) = 3.517 kW
		l Btu/s = 1055.1 W
Heat flux	q/A	1 Btu/h ft.^{2} = 3.1525 W/m^2
Heat-transfer coefficient	h	1 Btu/h ft.^{2} F = 5.678 W/m^2 K
Length	L	1 ft. = 0.3048 m
		1 in. = 2.54 cm
		1 mi = 1.6093 km
Mass	m	1 lb$_m$ = 0.4536 kg
		1 ton = 2240 lbm
		1 tonne (metric) = 1000 kg
Mass flow rate	$\dot{m}$	1 lb$_m$/h = 0.000126 kg/s
Power	$\dot{W}$	1 hp = 745.7 W
		1 kW = 3415 Btu/h
		1 ft. lb$_f$/s = 1.3558 W
		1 Btu/h = 0.293 W
Pressure	p	1 lb$_f$/in.^{2} (psi) = 6894.8 Pa (N/m^2)
		1 in. Hg = 3,386 Pa
		1 atm = 101,325 Pa (N/m^2) = 14.696 psi
Radiation	l	1 langley = 41,860 J/m^2
		1 langley/min = 697.4 W/m^2
Specific heat capacity	c	1 Btu/lb$_m$ °F = 4187 J/kg K
Internal energy or enthalpy	e or h	1 Btu/lb$_m$ = 2326.0 J/kg
		1 cal/g = 4184 J/kg
Temperature	T	T(°R) = (9/5)T(K)
		T(°F) = [T(°C)](9/5) + 32
		T(°F) = [T(K) − 273.15](9/5) + 32
Thermal conductivity	k	1 Btu/h ft. °F = 1.731 W/m K
Thermal resistance	R_{th}	1 h °F/Btu = 1.8958 K/W
Velocity	V	1 ft./s = 0.3048 m/s
		1 mi/h = 0.44703 m/s
Viscosity, dynamic	μ	1 lb$_m$/ft. s = 1.488 N s/m^2
		1 cP = 0.00100 N s/m^2
Viscosity, kinematic	ν	1 ft.^{2}/s = 0.09029 m^2/s
		1 ft.^{2}/h = 2.581 × 10^{-5} m^2/s
Volume	V	1 ft.^{3} = 0.02832 m^3 = 28.32 L
		1 barrel = 42 gal (U.S.)
		1 gal (U.S. liq.) = 3.785 L
		1 gal (U.K.) = 4.546 L
Volumetric flow rate	$\dot{Q}$	1 ft.^{3}/min (cfia) = 0.000472 m^3/s
		1 gal/min (GPM) = 0.0631 l/s