C. S. McCamy, Chairman
ASP Standards Committee

Solicitation of Comments on a Draft ASP Standard

Interested parties are requested to comment, by August 15, 1976, on the Fifth Draft of "American Society of Photogrammetry Usage of the International System of Units."

Members of the American Society of Photogrammetry and other interested parties are requested to comment on the following draft standard. Comments should be submitted to C. S. McCamy, Vice President for Science and Technology, Macbeth Division, Kollmorgen Corporation, P.O. Drawer 950, Newburgh, New York 12550. Comments must be received by August 15, 1976, and will be considered by the Committee in arriving at a final draft. The final draft prepared by the Committee will be submitted to the ASP Board of Direction for approval before publication as an ASP standard. The Committee expects the final standard to be particularly useful to the standards committees of the divisions of ASP in their preparation of draft standards for a number of aspects of photogrammetric engineering and remote sensing. Thus, this draft must be regarded as a starting point for standardization, rather than the full extent of standardization to be expected in ASP.

Present and past members of the ASP Standards Committee who contributed to the development of this draft are—

David Landen	William Pryor
C. S. McCamy (Chm.)	Robert Reeves
Gomer McNeil	Carl O. Thomas
Clarice Norton	John T. Smith, Jr.

The Committee was assisted by Louis E. Barbrow of the National Bureau of Standards, and Louis F. Sokol and Ernest John Rubin of the U. S. Metric Association, Inc., and received valuable comments on the fourth draft from Mr. Charles A. Whitten, Chairman of the Metric System Committee of the American Congress on Surveying and Mapping.

Fifth Draft

American Society of Photogrammetry Usage of the International System of Units

Foreword

It is the policy of the American Society of Photogrammetry to promote simplification and uniformity in usage of units of measurement by cooperating with other organizations in establishing common use of the International System of Units (Système International d'Unités) with the abbreviation SI and popularly known as the "metric system", and to use this system in all of its publications.

This standard was prepared by the Standards Committee of the American Society of Photogrammetry to promote use of the International System of Units, to make the policy of the Society known, and to make the rules of use of the SI units readily available to the members of the Society.

According to the policy of cooperating with other organizations in establishing common use of SI units, this document is largely based on and technically consistent with Standard 1000 of the International Organization for Standardization, except that the spelling "deka" has been used in place of "deca" to conform to American usage.

Introduction

In the 18th century weights and measures differed from one city to the next. The Articles of Confederation (1781) and the Constitution of the United States of America (1790) empowered Congress to establish uniform weights and measures. At the request of the National Assembly of France, in 1790, the French Academy of Sciences formulated a system of weights and measures known as the "metric system." The original "metre" was one ten-millionth of the distance from the north pole to the equator. The "litre" was a cube one-tenth metre on a side, and the "gramme" was the mass of water at 4°C in a cube one-hundredth of a metre on a side. Multiples and submultiples were all related by factors of ten. France adopted this system in 1799 and made it compulsory in 1840. It was readily adopted by scientists everywhere.

In 1866 the metric system was made lawful for use in the United States of America. The International Metric Convention, an international treaty (1875) ratified by the United States and 16 other nations, provided for physical standards of length and mass to be supplied to the signatory nations. Since 1893, metric standards have been the fundamental weights and measures of the United States and the customary units, such as pounds and yards, have been defined in terms of these.

The Conference Générale des Poids et Mesures (General Conference of Weights and Measures), abbreviated CGPM, is a diplomatic organization of adherents to the Convention, which meets every few years. It controls the International Bureau of Weights and Measures at Sevres, near Paris, which maintains physical standards. The U. S. National Bureau of Standards, founded in 1901, represents the United States at the CGPM and maintains our national physical standards. In 1960, CGPM extensively revised and simplified the system and adopted the name Le Système International d'Unités (International System of Units), with the international abbreviation SI, for his modernized system. Further improvements and additions were made in 1964, 1968, 1971, and 1975.

According to the Federal Register dated July 1, 1959, the U. S. foot was redefined as exactly 0.3048 metre, known as the international foot, but the foot based on the older definition was retained as the U.S. Survey Foot, equal to 1200/3937 metre (or 0.304 800 609 6 metre), for surveying. The existence of these two slightly different definitions made it particularly important that the American Society of Photogrammetry standardize its usage of units, basing all conversions of units of measurements directly related to surveying on the survey foot.

The use of the term "weight" to mean either force or mass is very confusing. In science, the "weight" of a body means the force caused by gravity. This force varies in time and space, observed values differing by over 0.5 per cent at various points on the earth. In common usage, "weight" usually means mass. Because of this dual usage, it is wise to avoid using the term "weight" unless its meaning is completely clear. It is important to know whether mass or force is intended, so the SI system clearly distinguishes two units, kilogram for mass and newton for force.

1. Scope

This standard gives rules for the use of units of the International System of Units, for their symbols, and for forming and selecting decimal multiples and submultiples of these units for application in photogrammetry and related fields. A list of conversion factors is given in the Appendix.

2. General

2.1 SI is based on seven base units, listed in Table 1, and two supplementary units, listed in Table 2. These units, designated "SI units," form a coherent system. In a coherent system of units the product or quotient of any two unit quantities is a unit of the resulting quantity.

Table 1. Base Units.

Quantity	Unit	Symbol
length	metre	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature	kelvin	K
luminous intensity	candela	cd
amount of substance	mole	mol

Table 2. Supplementary Units.

Quantity	Unit	Symbol
plane angle	radian	rad
solid angle	steradian	sr

2.2 The following definitions of the units are the authorized English translations of the international agreements in French:

metre—The metre is the length equal to 1 650 763.73 wavelengths in vacuum of the radiation corresponding to the transition between the levels of $2p_{10}$ and $5d_5$ of the krypton-86 atom.

(11th CGPM (1960), Resolution 6)

kilogram—The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram.

(1st CGPM (1889) and 3rd CGPM (1901)

second—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 caesium-133 atom.

(13th CGPM (1967), Resolution 1)

ampere—The ampere is that constant electric current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 metre apart in vacuum, would produce between these conductors a force equal to 2×10^{-7} newton per metre of length.

(9th CGPM (1948), Resolution 2)

kelvin—The kelvin, unit of thermodynamic temperature, is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water.

(13th CGPM (1967), Resolution 4)

mole—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. 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.

(14th CGPM (1971), Resolution 3)

candela—The candela is the luminous intensity, in the perpendicular direction, of a surface of 1/600 000 square metre of a black body at the temperature of freezing platinum under a pressure of 101 325 newtons per square metre.

(13th CGPM (1967), Resolution 5)

radian—The radian is the plane angle between two radii of a circle which cut off on the circumference an arc equal in length to the radius.

(ISO Recommendation R31, part 1, second edition, December 1965)

steradian—The steradian is the solid angle which, 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.

(ISO Recommendation R 31, part 1, second edition, December 1965)

2.3 Derived units are usually expressed in terms of base units; for example, velocity is expressed as metre per second (m/s). Some derived units have been given names and symbols; those approved by CGPM are listed in Table 3.

2.4 The names of decimal multiples and submultiples of SI units are formed by the use of the prefixes listed in Table 4. The symbols for these multiples and submultiples are formed by prefixing the symbols for the base units, supplementary units, or derived units with the symbols listed in Table 4.

TABLE 3. DERIVED UNITS HAVING NAMES APPROVED BY CGPM

Quantity	Name of derived SI unit	Symbol	Expressed in terms of base or supplementary SI units or in terms of other derived SI units
frequency	hertz	Hz	$1\ Hz = 1\ s^{-1}$
force	newton	N	$1\ N = 1\ kg \cdot m/s^2$
pressure, stress	pascal	Pa	$1\ Pa = 1\ N/m^2$
energy, work, quantity of heat	joule	J	$1\ J = 1\ N \cdot m$
power	watt	W	$1\ W = 1\ J/s$
electric charge, quantity of electricity	coulomb	C	$1\ C = 1\ A \cdot s$
electric potential, potential difference, tension, electromotive force	volt	V	$1\ V = 1\ J/C$
electric capacitance	farad	F	$1\ F = 1\ C/V$
electric resistance	ohm	Ω	$1\ \Omega = 1\ V/A$
electric conductance	siemens	S	$1\ S = 1\ \Omega^{-1}$
flux of magnetic induction, magnetic flux	weber	Wb	$1\ Wb = 1\ V \cdot s$
magnetic flux density, magnetic induction	tesla	T	$1\ T = 1\ Wb/m^2$
inductance	henry	H	$1\ H = 1\ Wb/A$
luminous flux	lumen	lm	$1\ lm = 1\ cd \cdot sr$
illuminance	lux	lx	$1\ lx = 1\ lm/m^2$
absorbed dose	gray	Gy	$1\ Gy = 1\ J/kg$
radioactivity	becquerel	Bq	$1\ Bq = 1\ s^{-1}$

TABLE 4. PREFIXES TO NAMES AND SYMBOLS OF MULTIPLES AND SUBMULTIPLES OF UNITS

Factor by Which the Unit is Multiplied	Name Prefix	Symbol Prefix
10^{18}	exa	E
10^{15}	peta	P
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10	deka	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a

A symbol and the attached prefix form a new symbol which can be raised to a power and can be combined with other symbols to form symbols for compound units. For example, 1 $mm^2 = (10^{-3}\ m)^2 = 10^{-6}\ m^2$.

Combinations of prefixes are not to be used; for example, use nm (nanometre), not mμm (millimicrometre).

3. Rules for Use of SI Units and Their Decimal Multiples and Submultiples

3.1 To avoid errors in calculation, it is necessary to use coherent units; therefore, in calculations, SI units should be used instead of their multiples or submultiples.

3.2 Prefixes representing a factor of 10 raised to a power that is a multiple of 3 are generally preferred. The prefixes "hecto", "deka", "deci", and "centi" are not preferred, but are used in some exceptional cases where a particular convenience results.

3.3 Only one prefix should be used to form a decimal multiple or submultiple of a derived unit and that prefix should not be attached to a unit in the denominator except for the base unit kg. Occasionally, convenience will require prefixes in both numerator and denominator or in the denominator only.

4. Numerical Values

4.1 A quantity is expressed by a numerical value and a unit. The unit, multiple, or submultiple is preferably chosen to permit the use of numerical values between 0.1 and 1000.

4.2 To permit convenient comparisons of values in a given context, such as within a table, a single unit, multiple, or submultiple should be used even though the numerical values extend beyond the preferred range of 0.1 to 1000.

5. Lists of Units for Various Quantities

To facilitate the application of this standard, several tables of quantities and appropriate units are given in the Appendix.

6. Exceptions

6.1 The base unit of mass is, for historical reasons, the only one that has a prefix in its name, "kilogram". In this singular case the multiples and submultiples are named by attaching prefixes to the word "gram" rather than to the SI unit.

6.2 The SI temperature scale is the International Thermodynamic Temperature Scale and the SI unit is the kelvin (not "degree kelvin"; Symbol K, not °K). The preferred unit of temperature and temperature interval is the kelvin; however, the Celsius scale (called the "centigrade" scale before 1948) is widely used and is permitted where it is considered distinctly more appropriate. One degree Celsius is exactly equal to one kelvin. A temperature $t°_C$ in degrees Celsius is exactly related to an International Thermodynamic Temperature t_K in kelvins as follows: $t°_C = t_K - 273.15$.

6.3 The preferred unit of time for technical calculations is the SI unit, the second. Hours, minutes, and seconds are used to indicate the time of day, and days and years are used for dates.

6.4 The radian is the SI unit for plane angle. The use of the arc degree and its decimal submultiples is permitted when the radian is inconvenient. The use of minutes and seconds of arc is discouraged by the CGPM, but these units may be used when they are more practical.

6.5 The SI unit for pressure and stress is the pascal, which is equivalent to one newton per square metre. The use of such units as kilogram-force per square centimetre, kilogram-force per square millimetre, bar and torr is discouraged and is to be discontinued.

6.6 The use of the non-SI units "calorie" and "micron" are to be discontinued in photogrammetry.

7. Typography and Style

7.1 Unit names are not capitalized, for example: metre, hertz, newton, and kelvin. Symbols are capitalized only when they derive from proper names; the symbols for the units in the above examples being m, Hz, N, and K. Name prefixes and symbol prefixes are not capitalized, except for symbol prefixes E, P, T, G, and M.

7.2 The plurals of unit names are formed in the manner customary in the English language except that unit names ending in s, x, or z remain unchanged: gram, grams; newton, newtons; siemens, siemens; lux, lux; hertz, hertz. Unit symbols are always singular; they are *symbols*, not words or abbreviations and are not followed by a period unless they are at the end of a sentence.

7.4 In derived unit symbols, a center dot indicates multiplication and a diagonal indicates division. Symbols to the left of the diagonal are in the numerator; those to the right are in the denominator and should be enclosed in parentheses. See examples in the Appendix.

8. Pronunciation

Pronunciation indicated in Webster's Third New International Dictionary of the English Language Unabridged is adopted.

The most common error in pronunciation is to pronounce the word "kilometre" to rhyme with "thermometer". The prefix "kilo", like all prefixes, is consistently pronounced with the accent on the first syllable. In this instance, the pronunciation given second in the above reference is adopted.

A Guide to Pronunication, for a number of terms that might have questionable pronunciation, is given in Appendix III.

Appendix I

Examples of Decimal Multiples and Submultiples of SI Units and of Some Other Units Which May Be Used.

			Units outside SI but recognized when needed for certain applications		
Quantity (1)	SI unit (2)	Selection of multiples of the SI unit (3)	Units (4)	Multiples of units given in column 4 (5)	Notes (6)
PART I: SPACE AND TIME					
plane angle	rad (radian)		° (degree)		1, 2
		mrad			
				′ (minute)	
				″ (second)	
		μrad			
			gon or grade		
solid angle	sr (steradian)				
length		km	nautical mile		3
	m (metre)				
		cm			
		mm			
		μm			
		nm			
area		km^2			4
		hm^2	hectare		
	m^2				
		dm^2			
		cm^2			
		mm^2			
volume	m^3				5
		dm^3	l (litre)		
		cm^3		ml	
				$1\ ml = 10^{-6} m^3$	
		mm^3		$= 1\ cm^3$	
time		ks	d (day)		6
	s (second)	ms	h (hour)		
		μs			
		ns	min (minute)		
angular velocity	rad/s				
velocity	m/s			km/h	7
				$1\ km/h = \frac{1}{3.6}\ m/s$	
acceleration	m/s^2				
PART II: PERIODIC AND ROTATIONAL PHENOMENA					
frequency		THz			
		GHz			
		MHz			
	Hz (hertz)	kHz			

Appendix I con't.

rotational frequency	r/s		r/min		8
PART III: MECHANICS					
mass	kg (kilogram)	Mg g mg μg	t metric ton		
linear density	kg/m	mg/m			
density (mass density)	kg/m^3		g/l		
momentum	kg·m/s				
moment of momentum, angular momentum	kg·m^2/s				
moment of inertia	kg·m^2				
force	N (newton)	MN kN mN μN			
moment of force	N·m	MN·m kN·m mN·m μN·m			
pressure	Pa (pascal)	GPa MPa kPa mPa μPa	bar	mbar	9
stress	Pa or N/m^2	GPa MPa or N/mm^2 kPa			
viscosity (dynamic)	Pa·s	mPa·s			10
kinematic viscosity	m^2/s	mm^2/s			11
surface tension	N/m	mN/m			
energy, work	J (joule)	TJ GJ MJ kJ mJ			12
power	W (watt)	GW MW kW mW μW			
PART IV: HEAT					
thermodynamic temperature	K (kelvin)				
Celsius temperature	°C (degree Celsius)				13
temperature interval	K				14
linear expansion coefficient	K^{-1}				
heat, quantity of heat		TJ GJ			

Appendix I con't.

		MJ	
	J	kJ	
		mJ	
heat flow rate	W	kW	
thermal conductivity	W/(m·K)		
coefficient of heat transfer	W/(m²·K)		
heat capacity	J/K	kJ/K	
specific heat capacity	J/(kg·K)	kJ/(kg·K)	
PART V: ELECTRICITY AND MAGNETISM			
electric current		kA	
	A (ampere)		
		mA	
		μA	
		nA	
		pA	
electric charge, quantity of electricity	C (coulomb)	kC	15
		μC	
		nC	
		pC	
electric field strength		MV/m	
		kV/m or V/mm	
	V/m	V/cm	
		mV/m	
		μV/m	
electric potential		MV	
potential difference (tension)	V (volt)	kV	
electromotive force		mV	
		μV	
capacitance	F (farad)		
		mF	
		μF	
		nF	
		pF	
magnetic flux density, magnetic induction	T (tesla)		
		mT	
		μT	
		nT	
magnetic flux (flux of magnetic induction)	Wb (weber	mWb	
self inductance, mutual inductance	H (henry)		
		mH	
		μH	
		nH	
		pH	
magnetization	A/m	kA/m or A/mm	
magnetic polarization	T	mT	
resistance		GΩ	
		MΩ	
	Ω (ohm)	kΩ	
		mΩ	
		μΩ	
conductance	S (siemens)	kS	
		mS	
		μS	
resistivity		GΩ·m	16

Appendix I con't.

		MΩ·m	
		kΩ·m	
	Ω·m		
		Ω·cm	
		mΩ·m	
		μΩ·m	
		nΩ·m	
conductivity		MS/m	
		kS/m	
	S/m		
reluctance	H^{-1}		
permeance	H		
impedance		MΩ	
modulus of		kΩ	
impedance	Ω		
reactance		mΩ	
resistance			
active power		TW	17
		GW	
		MW	
		kW	
	W		
		mW	
		μW	
		nW	
PART VI: LIGHT AND RELATED RADIATION			
wavelength		μm	18
	m	nm	
		pm	
radiant energy	J		
radiant flux,	W		
radiant power			
radiant intensity	W/sr		
radiance	$W/(sr \cdot m^2)$		
radiant exitance	W/m^2		
irradiance	W/m^2		
luminous intensity	cd (candela)		
luminous flux	lm (lumen)		
quantity of light	lm·s		
luminance	cd/m^2		
luminous exitance	lm/m^2		
illuminance	lx (lux)		
light exposure	lx·s		
luminoux efficacy	lm/W		
PART VII: ACOUSTICS			
period,	s		
periodic time		ms	
		μs	
frequency		MHz	
		kHz	
wavelength	m		
		mm	
density	kg/m^3		
(mass density)			
static pressure			
(instantaneous)		mPa	
sound pressure		μPa	
(instantaneous)	m/s		
sound particle		mm/s	
velocity			
(instantaneous)	m^3/s		

Appendix I con't.

volume velocity			
velocity of sound	m/s		
sound energy		kW	
flux,	W		
sound power		mW	
		μW	
		pW	
sound intensity	W/m^2		
		mW/m^2	
		$\mu W/m^2$	
		pW/m^2	
sound power level			dB (decibel)
sound pressure level			dB
sound reduction index			dB
sound transmission loss			

PART VIII: CHEMISTRY

amount of		kmol	
substance	mol (mole)		
		mmol	
		μmol	
molar mass	kg/mol		
		g/mol	
molar volume	m^3/mol		
		dm^3/mol	l/mol
		cm^3/mol	
concentration		mol/dm^3 or $kmol/m^3$	mol/l
	mol/m^3		
molality	mol/kg		
		mmol/kg	

1. The units degree and grade (or gon), with their decimal subdivisions, are recommended for use when the unit radian is not suitable.
   grade (g) or gon, 1^g = 1 gon = $\pi/200$ rad. 1 degree = $\pi/180$ rad
2. Curvature or degree of curve is the angle in degrees subtended at the center of curvature by an arc of 100 metres along the curve.
3. One international nautical mile = 1 852 m
4. ha (hectare), 1 ha = 10^4 m^2
   a (are), 1 a = 10^2 m^2
5. In 1964, the Conference Générale des Poids at Mesures declared that the name litre (l) may be used as a special name for the cubic decimetre (dm^3) and advised against the use of the name litre for high-precision measurements. Multiples and submultiples of the litre, other than the milliliter, should be avoided.
6. Other units such as week, month, and year (a) are in common use.
7. One knot is 1 international nautical mile per hour. 1 knot = 0.514 444 m/s, (exact value: 1852/3600 m/s).
8. Revolution per minute (symbol: r/min) and revolution per second (symbol: r/s) are widely used in specifications on rotating machinery, and the abbreviations commonly used are "rpm" and "rps".
9. One bar = 10^5 Pa
10. P (poise) 1 cP = 1 mPa · s
11. St (stokes) 1 cSt = 1 mm^2/s
12. The units W·h, kW·h, MW·h, GW·h, and TW·h are used in the field of consumption of electrical energy.
    The units keV, MeV, and GeV are used in atomic and nuclear physics and in accelerator technology.
13. The Celsius temperature t corresponding to a thermodynamic temperature T is equal to the difference $t = T - T_0$, where $T_0 = 273.15$ K.
14. For temperature interval, °C may be used instead of K.
15. 1 A·h = 3.6 kC
16. $\mu\Omega\cdot cm = 10^{-8}\ \Omega\cdot m$ is also used.
17. In electric power technology, "apparent power" is expressed in volt-amperes (VA) and "reactive power" is expressed in vars (var).
18. Å (ångström), 1 Å = 10^{-10}m = 0.1 nm = $10^{-4}\mu m$

Appendix I con't.

Appendix II
Conversion Factors

Each factor is written as a number followed by the letter E (a symbol for exponential notation), a plus or minus symbol, and two digits that indicate the power of ten by which the number must be multiplied. For example: 1.609344 E+03 means 1.609344×10^3, which is equal to 1609.344.

An asterisk (*) after a number indicates that it is an exact conversion and that subsequent digits would be zero. All other numbers listed have been rounded.

List of Conversion Tables

PLANE ANGLE

To convert from	To	Multiply by
degree	radian	1.745 329 E−02
minute	radian	2.908 882 E−04
second	radian	4.848 137 E−06
radian	degree	5.729 578 E+01
radian	minute	3.437 747 E+03
radian	second	2.062 648 E+05
gon (or grade)	radian	1.570 796 E−02
radian	gon (or grade)	6.366 198 E+01

LENGTH

To convert from given units to metre (m)	Multiply by
angstrom	1.000 000*E−10
chain (66 U.S. survey feet)	2.011 684 E+01
fathom (6 U.S. survey feet)	1.828 804 E+00
foot (international)	3.048 000*E−01
foot (U.S. survey)[a]	3.048 006 E−01
inch (international)	2.540 000*E−02
league (international nautical)	5.556 000*E+03
league (U.S. survey) (3 U.S. survey miles)	4.828 042 E+03
league (U.K. nautical)	5.559 552*E+03
microinch (international)	2.540 000*E−08
mil (international)	2.540 000*E−05
mile (international nautical)	1.852 000*E+03
mile (U.K. nautical)	1.853 184*E+03
mile (U.S. nautical)	1.852 000*E+03
mile (U.S. survey) = (5280 U.S. survey ft.)	1.609 347 E+03
pica (printer's)	4.217 518 E−03
point (printer's)	3.514 598*E−04
rod (16.5 U.S. survey feet)	5.029 210 E+00
yard (international)	9.144 000*E−01
yard (U.S. survey)	9.144 018 E−01

Appendix II con't.

AREA[b]

To convert from given units to square metre (m^2)	Multiply by
acre	4.046 873 E+03
are	1.000 000 E+02
square foot (international)	9.290 304*E−02
square foot (U.S. survey)	9.290 341 E−02
hectare	1.000 000 E+04
square inch (international)	6.451 600*E−04
square mile (U.S. survey)	2.589 998 E+06
section	2.589 998 E+06
township (of 36 sections)	9.323 994 E+07
square yard (international)	8.361 274 E−01
square yard (U.S. survey)	8.361 307 E−01

VOLUME (INCLUDES CAPACITY)

To convert from given units to cubic metre (m^3)	Multiply by
Acre-foot[c]	1.233 489 E+03
barrel (oil, 42 gal)	1.589 873 E−01
board foot	2.359 737 E−03
bushel (U.S.)	3.523 907 E−02
cup	2.365 882 E−04
fluid ounce (U.S.)	2.957 353 E−05
cubic foot (international)	2.831 685 E−02
gallon (Canadian liquid)	4.546 090 E−03
gallon (U.K. liquid)	4.546 092 E−03
gallon (U.S. dry)	4.404 884 E−03
gallon (U.S. liquid)	3.785 412 E−03
gill (U.K.)	1.420 654 E−04
gill (U.S.)	1.182 941 E−04
cubic inch[d] (international)	1.638 706 E−05
litre	1.000 000*E−03
ounce (U.K. fluid)	2.841 307 E−05
cubic yard (international)	7.645 549 E−01
cubic yard (U.S. survey)	7.645 594 E−01

TIME

To convert from given units to seconds	Multiply by
day (mean solar)	8.640 000 E+04
day (sidereal)	8.616 409 E+04
hour (mean solar)	3.600 000 E+03
hour (sidereal)	3.590 170 E+03
minute (mean solar)	6.000 000 E+01
minute (sidereal)	5.983 617 E+01
month (mean calendar)	2.628 000 E+06
second (sidereal)	9.972 696 E−01
year (calendar)	3.153 600 E+07
year (sidereal)	3.155 815 E+07
year (tropical) (mean solar)	3.155 693 E+07

VELOCITY (INCLUDES SPEED)

to convert from given units to metre/second (m/s)	Multiply by
foot/hour	8.466 667 E−05
foot/minute	5.080 000*E−03
foot/second	3.048 000*E−01
inch/second	2.540 000*E−02
kilometre/hour	2.777 778 E−01
knot (international)	5.144 444 E−01
mile/hour (U.S. survey)	4.470 409 E−01
mile/minute (U.S. survey)	2.682 245 E+01

Appendix II con't.

mile/second (U.S. survey)	1.609 347 E+03
To convert from mile/hour (U.S. survey) to kilometre/hour	1.609 347 E+00

ACCELERATION

To convert from given units to metre/second² (m/s²)	Multiply by
foot/second²	3.048 000*E−01
gal (galileo)	1.000 000*E−02

Standard free fall acceleration is 9.806 650*E+00 m/s².

VOLUME/TIME (INCLUDES FLOW)

To convert from given units to cubic metre/second (m³/s)	Multiply by
foot³/minute	4.719 474 E−04
gallon (U.S. liquid)/day	4.381 264 E−08
gallon (U.S. liquid)/minute	6.309 020 E−05

MASS

To convert from given units to kilogram (kg)	Multiply by
grain	6.479 891*E−05
gram	1.000 000*E−03
hundredweight (long)	5.080 235 E+01
hundredweight (short)	4.535 924 E+01
kilogram-force-second²/metre (mass)	9.806 650*E+00
ounce-mass (avoirdupois)	2.834 952 E−02
ounce-mass (troy or apothecary)	3.110 348 E−02
pound-mass (lbm avoirdupois)	4.535 924 E−01
pound-mass (troy or apothecary)	3.732 417 E−01
slug	1.459 390 E+01
ton (assay)	2.916 667 E−02
ton (long, 2240 lbm)	1.016 047 E+03
ton (metric)	1.000 000*E+03
ton (short, 2000 lbm)	9.071 847 E+02
tonne	1.000 000*E+03

MASS/VOLUME (INCLUDES DENSITY AND MASS CAPACITY)

To convert from given units to kilogram/cubic metre (kg/m³)	Multiply by
gram/cubic centimetre	1.000 000*E+03
ounce (avoirdupois)/gallon (U.K. liquid)	6.236 021 E+00
ounce (avoirdupois)/gallon (U.S. liquid)	7.489 152 E+00
ounce (avoirdupois-mass)/cubic inch	1.729 994 E+03
pound-mass/cubic foot	1.601 846 E+01
pound-mass/cubic inch	2.767 990 E+04
pound-mass/gallon (U.K. liquid)	9.977 633 E+01
pound-mass/gallon (U.S. liquid)	1.198 264 E+02
ton (long, mass)/cubic yard	1.328 939 E+03

FORCE

To convert from given units to newton (N)	Multiply by
dyne	1.000 000*E−05
kilogram-force	9.806 650*E+00
kilopond	9.806 650*E+00
kip	4.448 222 E+03
ounce-force (avoirdupois)	2.780 139 E−01
pound-force (lbf avoirdupois)	4.448 222 E+00
poundal	1.382 550 E−01

Appendix II con't.

PRESSURE OR STRESS (FORCE/AREA)

To convert from given units to pascal (Pa)	Multiply by
atmosphere (normal = 760 torr)	1.013 25 E+05
atmosphere (technical = 1 kgf/cm²)	9.806 650*E+04
bar	1.000 000*E+05
centimetre of mercury (0°C)	1.333 22 E+03
centimetre of water (4°C)	9.806 38 E+01
decibar	1.000 000*E+04
dyne/sq. centimetre	1.000 000*E−01
foot of water (39.2°F)	2.988 98 E+03
gram-force/sq. centimetre	9.806 650*E+01
inch of mercury (32°F)	3.386 389 E+03
inch of mercury (60°F)	3.376 85 E+03
inch of water (39.2°F)	2.490 82 E+02
inch of water (60°F)	2.488 4 E+02
kilogram-force/sq. centimetre	9.806 650*E+04
kilogram-force/sq. metre	9.806 650*E+00
kilogram-force/sq. millimetre	9.806 650*E+06
millibar	1.000 000*E+02
millimetre of mercury (0°C)	1.333 22 E+02
poundal/sq. foot	1.488 164 E+00
pound-force/sq. foot	4.788 026 E+01
pound-force/sq. inch (psi)	6.894 757 E+03
psi	6.894 757 E+03
torr (mm Hg, 0°C)	1.333 224 E+02

BENDING MOMENT OR TORQUE

To convert from given units to newton-metre (N·m)	Multiply by
ounce-force-inch	7.061 552 E−03
pound-force-inch	1.129 848 E−01
pound-force-foot	1.355 818 E+00

VISCOSITY

To convert from	To	Multiply by
centipoise	pascal-second (Pa·s)	1.000 000*E−03
centistokes	metre/second (m/s)	1.000 000*E−06
poise	pascal-second (Pa·s)	1.000 000*E−01
rhe	metre/newton-second [m/(n·s)]	1.000 000*E+01
stokes	metre/second (m/s)	1.000 000*E−04

ENERGY (INCLUDES WORK)

To convert from given units to joule (J)	Multiply by
British thermal unit (International Table)	1.055 056 E+03
British thermal unit (thermochemical)	1.054 350 E+03
calorie (International Table)	4.186 800*E+00
calorie (thermochemical)	4.184 000*E+00
calorie (kg, International Table)	4.186 800*E+03
calorie (kg, thermochemical)	4.184 000*E+03
erg	1.000 000*E−07
foot-pound-force	1.355 818 E+00
foot-poundal	4.214 011 E−02
kilowatt-hour	3.600 000*E+06
watt-hour	3.600 000*E+03
watt-second	1.000 000*E+00

POWER

To convert from given units to watt (W)	Multiply by
Btu (International Table)/hour	2.930 711 E−01
calorie (thermochemical)/second	4.184 000*E+00
calorie (thermochemical)/minute	6.973 333 E−02

Appendix II con't.

erg/second	1.000 000*E−07
foot-pound-force/hour	3.766 161 E−04
foot-pound-force/minute	2.259 697 E−02
foot-pound-force/second	1.355 818 E+00
horsepower (550 ft·lbf/s)	7.456 999 E+02
horsepower (boiler)	9.809 50 E+03
horsepower (electric)	7.460 000*E+02
horsepower (metric)	7.354 99 E+02
horsepower (water)	7.460 43 E+02
horsepower (U.K.)	7.457 0 E+02
kilocalorie (thermochemical)/minute	6.973 333 E+01
kilocalorie (thermochemical)/second	4.184 000*E+03

TEMPERATURE

To convert from	To	Formula
degree Celsius	kelvin (K)	$t_K = t_{°C} + 273.15$
degree Fahrenheit	kelvin (K)	$t_K = (t_{°F} + 459.67)/1.8$
degree Rankine	kelvin (K)	$t_K = t_{°R}/1.8$
degree Fahrenheit	degree Celsius	$t_{°C} = (t_{°F} - 32)/1.8$
kelvin	degree Celsius	$t_{°C} = t_K - 273.15$

HEAT

To convert from	To	Multiply by
Btu (International Table)·in./(s·ft²·°F) (k, thermal conductivity)	watt/metre-kelvin [W/(m·k)]	5.192 204 E+02
Btu (International Table)·in./(h·ft²·°F) (k, thermal conductivity)	watt/metre-kelvin [W/(m·K)]	1.442 279 E−01
Btu (International Table)/ft²	joule/metre² (J/m)	1.135 653 E+04
Btu (International Table)/(h · ft² · °F) (C, thermal conductance)	watt/metre²-kelvin [W/(m²·K)]	5.678 263 E+00
Btu (International Table)/pound-mass	joule/kilogram (J/kg)	2.326 000*E+03
Btu (International Table)/(lbm·°F) (c, heat capacity)	joule/kilogram-kelvin [J/(kg·K)]	4.186 800*E+03
Btu (International Table)/(s·ft²·°F)	watt/metre²-kelvin [W/(m²·K)]	2.044 175 E+04
cal (International Table)/g	joule/kilogram (J/kg)	4.186 800*E+03
cal (International Table)/(g·°C)	joule/kilogram-kelvin [J/(kg·K)]	4.186 800*E+03
cal (thermochemical)/g	joule/kilogram (J/kg)	4.184 000*E+03
cal (thermochemical)/(g·°C)	joule/kilogram-kelvin [J/(kg·K)]	4.184 000*E+03

ELECTRICITY AND MAGNETISM

To convert from	To	Multiply by
abampere	ampere (A)	1.000 000*E+01
abcoulomb	coulomb (C)	1.000 000*E+01
abfarad	farad (F)	1.000 000*E+09
abhenry	henry (H)	1.000 000*E−09
abmho	siemens (S)	1.000 000*E+09
abohm	ohm (Ω)	1.000 000*E−09
abvolt	volt (V)	1.000 000*E−08
ampere-hour	coulomb (C)	3.600 000*E+03
EMU of capacitance	farad (F)	1.000 000*E+09
EMU of current	ampere (A)	1.000 000*E+01
EMU of electric potential	volt (V)	1.000 000*E−08
EMUof inductance	henry (H)	1.000 000*E−09
EMU of resistance	ohm (Ω)	1.000 000*E−09
ESU of capacitance	farad (F)	1.112 650 E−12
ESU of current	ampere (A)	3.335 6 E−10
ESU of electric potential	volt (V)	2.997 9 E+02
ESU of inductance	henry (H)	8.987 554 E+11
ESU of resistance	ohm (Ω)	8.987 554 E+11
farad, international U.S. (F_{INT-US})	farad (F)	9.995 05 E−01
faraday (based on carbon-12)	coulomb (C)	9.648 70 E+04
faraday (chemical)	coulomb (C)	9.649 57 E+04
faraday (physical)	coulomb (C)	9.652 19 E+04

Appendix II con't.

gauss	tesla (T)	1.000 000*E−04
gilbert	ampere-turn	7.957 747 E−01
maxwell	weber (Wb)	1.000 000*E−08
oersted	ampere/metre (A/m)	7.957 747 E+01
statampere	ampere (A)	3.335 640 E−10
statcoulomb	coulomb (C)	3.335 640 E−10
statfarad	farad (F)	1.112 650 E−12
stathenry	henry (H)	8.987 554 E+11
statmho	siemens (S)	1.112 650 E−12
statohm	ohm (Ω)	8.987 554 E+11
statvolt	volt (V)	2.997 925 E+02
unit pole	weber (Wb)	1.256 637 E−07

LIGHT

To convert from	To	Multiply by
footcandle	lumen/metre² (lm/m²)	1.076 391 E+01
footcandle	lux (lx)	1.076 391 E+01
footlambert	candela/metre² (cd/m²)	3.426 259 E+00
lux	lumen/metre² (lm/m²)	1.000 000*E+00

[a] The exact conversion factor is 1200/3937 (= 3.048 006 096*E−01).
[b] The conversions for acre, square mile, section, and township are based on the U.S. survey foot.
[c] Based on the U.S. survey foot.
[d] The exact conversion factor is 1.638 706 4*E−05.

Appendix III
Guide to Pronunciation*

Pronounce	As In	Pronounce	As In
UNITS		PREFIXES	
ampere	*am pier*	exa	*ex u*p
candela	*can Dela*ware (accent on "del")	peta	*peta*l
Celsius	*sell see us*	tera	*terra*-cotta
erg	h*er* get	giga	*jig u*p
farad	*fa*n *rad*ical	mega	*mega*phone
gon	*go no*	kilo	*kill oh*
joule	*jewel*	hecto	*heck toe*
lux	*luck s*and	deka	*deck u*p
pica	*pie cut*	deci	*deci*mal
radian	*radian*t	centi	*senti*ment
siemens	*seamen's*	milli	*mill i*t
steradian	(The "e" is unstressed as in "duchess".)	micro	*micro*phone
		nano	b*an*an*a oh*
tesla	*tes*t *luck*	pico	*peek oh*
		femto	*fem*inine *toe*
		atto	*att*ic *oh*

* The accent is on the first syllable of all Prefixes. Unless otherwise indicated, the accent is on the first syllable of all of the Units listed here.