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Adoption of SI units

The Royal Society Conference of Editors, in which the Editors of the *Journal* took part, have recently recommended (1) that the system of units known as SI should be adopted in all scientific and technical journals, (2) that, in order to keep to a minimum the difficulties that will inevitably arise during the period of transition, the change-over should be effected as quickly as possible.

These recommendations are associated with the British Government's policy of promoting the general adoption of SI units in the U.K. A similar move towards the adoption of SI units in scientific and engineering work is in progress in the U.S.A. The Editors of the *Journal* wish to commend these proposals to the authors of papers to be submitted for publication. However, they appreciate that a rapid and rigidly timed transition to SI units would make difficulties for authors from countries in which alternative systems of units are used. The Editors are of the opinion that it would be wrong to insist that all authors should henceforth use SI in the papers that they submit to the *Journal*; but they recommend the use of SI units unless there are good reasons in favour of an alternative system.

Readers of the *Journal* may find it convenient to have available the following description of SI units, which is taken from the Royal Society pamphlet *Metrication in Scientific Journals.* Copies of the pamphlet may be obtained from the Executive Secretary of the Royal Society, 6 Carlton House Terrace, London, S.W. 1 (price for bulk orders £2 per 100).

SI units

SI (which is the abbreviation in many languages for Système International d'Unités) is an extension and refinement of the traditional metric system. It embodies features which make it logically superior to any other system as well as practically more convenient: it is rational, coherent and comprehensive.

The metric system which had spread to several countries in the aftermath of the French Revolution, began to be adopted in scientific work in the U.K. in the last quarter of the nineteenth century. Its use extended more and more widely, although a few branches of science remain where Imperial Units have continued to predominate. It is fortunate that now that the time has come to discard completely the time-honoured native units (which are not without their advantages), there is to hand a fully developed International System to take their place. Over the years much thought has been given to extending and improving the metric system until finally in 1960 the Conférence Générale des Poids et Mesures, the body responsible for maintaining standards of measurements (of which the U.K. is an active participant), formally approved SI. Already nearly thirty countries have decided to make it the only legally accepted system and it is clearly destined to become the universal currency of science and commerce. In many spheres in the U.K. (schools, universities, industry) the adoption of SI is being actively encouraged. The Conference of Editors is anxious that the journals devoted to science and engineering should seize the opportunity of playing a crucial role in helping to end the confusion and wastefulness (both mental and material) resulting from the present multiplicity of units.

The main features of SI are as follows:

(1) There are six basic units (see below), the metre and kilogramme taking the place of the centimetre and gramme of the old metric system.

(2) The unit of force, the newton (kg m s^{-2}), is independent of the Earth's gravitation, and the often confusing introduction, in some branches of science and technology, of g into equations is no longer necessary.

(3) The unit of energy in all forms is the joule (newton × metre), and of power the joule per second (watt); thus the variously defined calories, together with the kilowatt hour, the B.t.u. and the horsepower are all superseded.

(4) 'Electrostatic' and 'electromagnetic' units are replaced by SI electrical units.

(5) Multiples of units are normally to be restricted to steps of a thousand and similarly fractions to steps of a thousandth.

Lists are appended of the basic SI units, of some derived SI units, of compatible units, and also examples of units which run counter to SI, the use of which is accordingly to be actively discouraged. Also listed are the names and symbols of the prefixes representing numerical factors: these are both convenient in obviating the need to write large numbers of zeros or in some instances high powers of 10, and also helpful in establishing familiarity with the numerical framework of modern science. It will be noted that the recommended prefixes are limited to $10^{\pm 3n}$.

The rate of the change-over towards complete metrication will vary from journal to journal, depending on the subjects covered and the extent to which the metric system already holds sway. In certain branches of science and engineering editors may decide to proceed to their target along the following route (with equivalent values given in parentheses):

non-metric (SI) → SI (non-metric) → SI
(stage I) (stage II) (stage III)

In some branches full metrication will have to wait upon the installation of metric machinery and equipment. (Where measurements are expressed in the form of instrument readings they should be so recorded and a conversion factor quoted.)

In many journals, on the other hand, change-over to SI units can be achieved in one step, and the experience of some editors and authors where changes have already been introduced is that such changes are more readily accepted than would have been supposed before their introduction.

Whatever the particular circumstances, it is hoped that editors will play a positive part in encouraging their authors to adopt the International System of units. When it becomes fully established in all disciplines the advantages will be enormous.

Basic SI units

Physical quantity	Name of unit	Symbol for unit
Length	metre	m
Mass	kilogramme	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	degree Kelvin	°K
Luminous intensity	candela	cd

Symbols for units do not take a plural form.

Supplementary units

These units are dimensionless.

Physical quantity	Name of unit	Symbol for unit
Plane angle	radian	rad
Solid angle	steradian	sr

Derived SI units with special names

Physical quantity	Name of unit	Symbol for unit	Definition of unit
Energy	joule	J	kg m^2 s^{-2}
Force	newton	N	kg m s^{-2} = J m^{-1}
Power	watt	W	kg m^2 s^{-3} = J s^{-1}
Electric charge	coulomb	C	A s
Electric potential difference	volt	V	kg m^2 s^{-3} A^{-1} = J A^{-1} s^{-1}
Electric resistance	ohm	Ω	kg m^2 s^{-3} A^{-2} = V A^{-1}
Electric capacitance	farad	F	A^2 s^4 kg^{-1} m^{-2} = A s V^{-1}
Magnetic flux	weber	Wb	kg m^2 s^{-2} A^{-1} = V s
Inductance	henry	H	kg m^2 s^{-2} A^{-2} = V s A^{-1}
Magnetic flux density	tesla	T	kg s^{-2} A^{-1} = V s m^{-2}
Luminous flux	lumen	lm	cd sr
Illumination	lux	lx	cd sr m^{-2}
Frequency	hertz	Hz	cycle per second
Customary temperature, t	degree Celsius	°C	t/°C = T/°K − 273·15

Fractions and multiples

Fraction	Prefix	Symbol	Multiple	Prefix	Symbol
10^{-1}	deci	d	10	deka	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^{-18}	atto	a			

* To be restricted to instances where there is a strongly felt need, such as may be experienced in the early days of metrication in favour of the centimetre as the unit of length in certain biological measurements.

Compound prefixes should not be used, e.g. 10^{-9} metre is represented by

$$1\ \text{nm}, \quad \textit{not} \quad 1\ \text{m}\mu\text{m}.$$

The attaching of a prefix to a unit in effect constitutes a new unit, e.g.

$$1\ \text{km}^2 = 1\ (\text{km})^2 = 10^6\ \text{m}^2$$
$$\textit{not} \quad 1\ \text{k}(\text{m}^2) = 10^3\ \text{m}^2.$$

Where possible any numerical prefix should appear in the numerator of an expression.

Examples of other derived SI units

Physical quantity	SI unit	Symbol for unit
Area	square metre	m^2
Volume	cubic metre	m^3
Density	kilogramme per cubic metre	kg m^{-3}
Velocity	metre per second	m s^{-1}
Angular velocity	radian per second	rad s^{-1}
Acceleration	metre per second squared	m s^{-2}
Pressure	newton per square metre	N m^{-2}
Kinematic viscosity, diffusion coefficient	square metre per second	$\text{m}^2\ \text{s}^{-1}$
Dynamic viscosity	newton second per square metre	N s m^{-2}
Electric field strength	volt per metre	V m^{-1}
Magnetic field strength	ampere per metre	A m^{-1}
Luminance	candela per square metre	cd m^{-2}

Units to be allowed in conjunction with SI

Physical quantity	Name of unit	Symbol for unit	Definition of unit
Length	parsec	pc	$30{\cdot}87 \times 10^{15}$ m
Area	barn	b	10^{-28} m^2
	hectare	ha	10^4 m^2
Volume	litre	l	10^{-3} m^3 = dm^3
Pressure	bar	bar	10^5 N m^{-2}
Mass	tonne	t	10^3 kg = Mg
Kinematic viscosity, diffusion coefficient	stokes	St	10^{-4} m^2 s^{-1}
Dynamic viscosity	poise	P	10^{-1} kg m^{-1} s^{-1}
Magnetic flux density (magnetic induction)	gauss	G	10^{-4} T
Radioactivity	curie	Ci	37×10^9 s^{-1}
Energy	electronvolt	eV	$1{\cdot}6021 \times 10^{-19}$ J

The common units of time (e.g. hour, year) will persist, and also, in appropriate contexts, the angular degree.

Until such time as a new name may be adopted for the kilogramme as the basic unit of mass, the gramme will often be used, both as an elementary unit (to avoid the absurdity of mkg) and in association with numerical prefixes, e.g. μg.

Examples of units contrary to SI, with their equivalents†

Physical quantity	Unit	Equivalent
Length	ångström	10^{-10} m
	inch	0·0254 m
	foot	0·3048 m
	yard	0·9144 m
	mile	1·609 34 km
	nautical mile	1·853 18 km
Area	square inch	645·16 mm^2
	square foot	0·092 903 m^2
	square yard	0·836 127 m^2
	square mile	2·589 99 km^2
Volume	cubic inch	$1{\cdot}638\ 71 \times 10^{-5}\ \mathrm{m}^3$
	cubic foot	0·028 316 8 m^3
	U.K. gallon	0·004 546 092 m^3
Mass	pound	0·453 592 37 kg
	slug	14·593 9 kg
Density	pound/cubic inch	$2{\cdot}767\ 99 \times 10^{4}\ \mathrm{kg\ m^{-3}}$
	pound/cubic foot	16·0185 kg m^{-3}
Force	dyne	10^{-5} N
	poundal	0·138 255 N
	pound-force	4·448 22 N
	kilogramme-force	9·806 65 N
Pressure	atmosphere	101·325 kN m^{-2}
	torr	133·322 N m^{-2}
	pound (f)/sq.in.	6894·76 N m^{-2}
Energy	erg	10^{-7} J
	calorie (I.T.)	4·1868 J
	calorie (15 °C)	4·1855 J
	calorie (thermochemical)	4·184 J
	B.t.u.	1055·06 J
	foot poundal	0·042 140 1 J
	foot pound (f)	1·355 82 J
Power	horse power	745·700 W
Temperature	degree Rankine	$\frac{5}{9}$ °K
	degree Fahrenheit	$t/°\mathrm{F} = \frac{9}{5}T/°\mathrm{C} + 32$

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† Fuller lists are to be found in the National Physical Laboratory's *Changing to the Metric System* (Anderton & Brigg). London: H.M.S.O. (1966).