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Quantities and units —

Part 4: **Mechanics**

Grandeurs et unités —

Partie 4: Mécanique

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 80000-4 was prepared by Technical Committee ISO/TC 12, *Quantities, units, symbols, conversion factors*, in collaboration with IEC/TC 25, *Quantities and units, and their letter symbols*.

This first edition cancels and replaces the second edition of ISO 31-3:1992. The major technical changes from the previous standards are the following:

— the presentation of *numerical statements* has been changed;

— the *normative references* have been changed;

— quantities from *analytical mechanics* have been added to the list of quantities.

ISO 80000 consists of the following parts, under the general title *Quantities and units*:

— *Part 1: General*

— *Part 2: Mathematical signs and symbols for use in the natural sciences and technology*

— *Part 3: Space and time*

— *Part 4: Mechanics*

— *Part 5: Thermodynamics*

— *Part 7: Light*

— *Part 8: Acoustics*

— *Part 9: Physical chemistry and molecular physics*

— *Part 10: Atomic and nuclear physics*

— *Part 11: Characteristic numbers*

— *Part 12: Solid state physics*

IEC 80000 consists of the following parts, under the general title *Quantities and units*:

— *Part 6: Electromagnetism*

— *Part 13: Information science and technology*

— *Part 14: Telebiometrics related to human physiology*

Introduction

0.1 Arrangement of the tables

The tables of quantities and units in this International Standard are arranged so that the quantities are presented on the left-hand pages and the units on the corresponding right-hand pages.

All units between two full lines on the right-hand pages belong to the quantities between the corresponding full lines on the left-hand pages.

Where the numbering of an item has been changed in the revision of a part of ISO 31, the number in the preceding edition is shown in parentheses on the left-hand page under the new number for the quantity; a dash is used to indicate that the item in question did not appear in the preceding edition.

0.2 Tables of quantities

The names in English and in French of the most important quantities within the field of this International Standard are given together with their symbols and, in most cases, their definitions. These names and symbols are recommendations. The definitions are given for identification of the quantities in the International System of Quantities (ISQ), listed on the left-hand pages of the table; they are not intended to be complete.

The scalar, vectorial or tensorial character of quantities is pointed out, especially when this is needed for the definitions.

In most cases only one name and only one symbol for the quantity are given; where two or more names or two or more symbols are given for one quantity and no special distinction is made, they are on an equal footing. When two types of italic letters exist (for example as with ϑ and θ; φ and ϕ; *a* and a; *g* and g) only one of these is given. This does not mean that the other is not equally acceptable. It is not recommended to give such variants different meanings. A symbol within parentheses implies that it is a reserve symbol, to be used when, in a particular context, the main symbol is in use with a different meaning.

In this English edition, the quantity names in French are printed in an italic font, and are preceded by *fr*. The gender of the French name is indicated by (m) for male and (f) for female, immediately after the noun in the French name.

0.3 Tables of units

0.3.1 General

The names of units for the corresponding quantities are given together with the international symbols and the definitions. These unit names are language-dependent, but the symbols are international and the same in all languages. For further information, see the SI Brochure (7th edition 1998) from BIPM and ISO 80000-1[1)].

The units are arranged in the following way.

a) The coherent SI units are given first. The SI units have been adopted by the General Conference on Weights and Measures (Conférence Générale des Poids et Mesures, CGPM). The use of coherent SI units

1) To be published.

is recommended; decimal multiples and submultiples formed with the SI prefixes are recommended even though not explicitly mentioned.

b) Some non-SI units are then given, being those accepted by the International Committee for Weights and Measures (Comité International des Poids et Mesures, CIPM), or by the International Organization of Legal Metrology (Organisation Internationale de Métrologie Légale, OIML), or by ISO and IEC, for use with the SI.

   Such units are separated from the SI units in the item by use of a broken line between the SI units and the other units.

c) Non-SI units currently accepted by the CIPM for use with the SI are given in small print (smaller than the text size) in the "Conversion factors and remarks" column.

d) Non-SI units that are not recommended are given only in annexes in some parts of this International Standard. These annexes are informative, in the first place for the conversion factors, and are not integral parts of the standard. These deprecated units are arranged in two groups:

   1) units in the CGS system with special names;

   2) units based on the foot, pound, second, and some other related units.

e) Other non-SI units given for information, especially regarding the conversion factors, are given in another informative annex.

0.3.2 Remark on units for quantities of dimension one, or dimensionless quantities

The coherent unit for any quantity of dimension one, also called a dimensionless quantity, is the number one, symbol 1. When the value of such a quantity is expressed, the unit symbol 1 is generally not written out explicitly.

EXAMPLE 1 Refractive index $n = 1{,}53 \times 1 = 1{,}53$

Prefixes shall not be used to form multiples or submultiples of the unit one. Instead of prefixes, powers of 10 are recommended.

EXAMPLE 2 Reynolds number $Re = 1{,}32 \times 10^3$

Considering that plane angle is generally expressed as the ratio of two lengths and solid angle as the ratio of two areas, in 1995 the CGPM specified that, in the SI, the radian, symbol rad, and steradian, symbol sr, are dimensionless derived units. This implies that the quantities plane angle and solid angle are considered as derived quantities of dimension one. The units radian and steradian are thus equal to one; they may either be omitted, or they may be used in expressions for derived units to facilitate distinction between quantities of different kind but having the same dimension.

0.4 Numerical statements in this International Standard

The sign $=$ is used to denote "is exactly equal to", the sign $\approx$ is used to denote "is approximately equal to", and the sign $:=$ is used to denote "is by definition equal to".

Numerical values of physical quantities that have been experimentally determined always have an associated measurement uncertainty. This uncertainty should always be specified. In this International Standard, the magnitude of the uncertainty is represented as in the following example.

EXAMPLE $l = 2{,}347\,82(32)$ m

In this example, $l = a(b)$ m, the numerical value of the uncertainty b indicated in parentheses is assumed to apply to the last (and least significant) digits of the numerical value a of the length l. This notation is used when b represents the standard uncertainty (estimated standard deviation) in the last digits of a. The numerical example given above may be interpreted to mean that the best estimate of the numerical value of the length l (when l is expressed in the unit metre) is 2,347 82, and that the unknown value of l is believed to lie between (2,347 82 − 0,000 32) m and (2,347 82 + 0,000 32) m, with a probability determined by the standard uncertainty 0,000 32 m and the probability distribution of the values of l.

Quantities and units —

Part 4:
Mechanics

1 Scope

ISO 80000-4 gives the names, symbols and definitions for quantities and units of classical mechanics. Where appropriate, conversion factors are also given.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 31-4:1992, *Quantities and units — Part 4: Heat* [2)]

ISO 31-11:1992, *Quantities and units — Part 11: Mathematical signs and symbols for use in the physical sciences and technology* [3)]

ISO 80000-3:2006, *Quantities and units — Part 3: Space and time* [4)]

3 Names, symbols and definitions

The names, symbols, and definitions for quantities and units of mechanics are given on the following pages.

2) To be revised as ISO 80000-5.

3) To be revised as ISO 80000-2.

4) Revision of ISO 31-1:1992 and ISO 31-2:1992.

MECHANICS				QUANTITIES
Item No.	**Name**	**Symbol**	**Definition**	**Remarks**
4-1 (*3-1*)	mass *fr masse* (f)	m	mass is one of the seven base quantities in the International System of Quantities, ISQ, on which the International System of Units, SI, is based	Mass is the quantity that can often be measured with a balance.
4-2 (*3-2*)	mass density, density *fr masse* (f) *volumique*	ρ	$\rho = \mathrm{d}m/\mathrm{d}V$ where m is mass (item 4-1) and V is volume (ISO 80000-3:2006, item 3-4)	The systematic name, volumic mass, is not given since the term mass density or density is the established term in the English language.
4-3 (*3-3*)	relative mass density, relative density *fr densité* (f), *masse* (f) *volumique* *relative*	d	$d = \rho/\rho_0$ where ρ is the mass density (item 4-2) of a substance and ρ_0 is the mass density (item 4-2) of a reference substance under conditions that should be specified for both substances	For ρ_0, the mass density of liquid water (1 000 kg/m^3) is often used.
4-4 (*3-4*)	specific volume, massic volume *fr volume* (m) *massique*	v	$v = 1/\rho$ where ρ is mass density (item 4-2)	
4-5 (*3-6*)	surface density, areic mass *fr masse* (f) *surfacique*	ρ_A	$\rho_A = \mathrm{d}m/\mathrm{d}A$ where m is mass (item 4-1) and A is area (ISO 80000-3:2006, item 3-3)	Surface mass density is also used. The name "grammage" should not be used for this quantity.
4-6 (*3-5*)	linear density, lineic mass *fr masse* (f) *linéique*	ρ_l	$\rho_l = \mathrm{d}m/\mathrm{d}l$ where m is mass (item 4-1) and l is length (ISO 80000-3:2006, item 3-1.1)	Linear mass density is also used.
4-7 (*3-7*)	mass moment of inertia, moment of inertia *fr moment* (m) *d'inertie*	I, J	$J_\mathrm{Q} = \int r_\mathrm{Q}^2\, \mathrm{d}m$ where r_Q is the radial distance (ISO 80000-3:2006, item 3-1.6) from a Q-axis and m is mass (item 4-1) ***J*** also appears as a tensor of the second order with $J_{xx} = \int (y^2 + z^2)\, \mathrm{d}m$, cycl., cycl. and $J_{xy} = -\int xy\, \mathrm{d}m$, cycl., cycl., where x, y, and z are cartesian coordinates (ISO 80000-3:2006, item 3-1.10)	This quantity should be distinguished from item 4-20, the second (axial or polar) moment of area. If there is a risk of confusion, the symbol J should be used for item 4-7 and I for item 4-20.

UNITS				MECHANICS
Item No.	**Name**	**International symbol**	**Definition**	**Conversion factors and remarks**
4-1.a	kilogram	kg	unit of mass; it is equal to the mass of the international prototype of the kilogram [3rd CGPM (1901)]	Names of decimal multiples and submultiples of the unit of mass are formed by attaching prefixes to the name “gram” [CIPM (1967)]. $1\ \text{g} = 0{,}001\ \text{kg}$
4-1.b	tonne	t	$1\ \text{t} := 1\ 000\ \text{kg}$	In the English language, this unit is also called metric ton.
4-2.a	kilogram per cubic metre	kg/m^3		
4-2.b	tonne per cubic metre	t/m^3		$1\ \text{t/m}^3 = 1\ 000\ \text{kg/m}^3 = 1\ \text{g/cm}^3$
4-2.c	kilogram per litre	kg/l		$1\ \text{kg/l} = 1\ 000\ \text{kg/m}^3$
4-3.a	one	1		See the Introduction, 0.3.2.
4-4.a	cubic metre per kilogram	m^3/kg		
4-5.a	kilogram per square metre	kg/m^2		
4-6.a	kilogram per metre	kg/m		
4-7.a	kilogram metre squared	$\text{kg} \cdot \text{m}^2$		

(*continued*)

MECHANICS				QUANTITIES
Item No.	**Name**	**Symbol**	**Definition**	**Remarks**
4-8 (*3-8*)	momentum *fr quantité* (f) *de mouvement*	$\boldsymbol{p}$	for a particle $\boldsymbol{p} = m\,\boldsymbol{v}$ where m is mass (item 4-1) and $\boldsymbol{v}$ is velocity (ISO 80000-3:2006, item 3-8.1)	
4-9.1 (*3-9.1*)	force *fr force* (f)	$\boldsymbol{F}$	$\boldsymbol{F} = \mathrm{d}\boldsymbol{p}/\mathrm{d}t$ where $\boldsymbol{p}$ is momentum (item 4-8) and t is time (ISO 80000-3:2006, item 3-7)	If the mass of a particle is constant then $\boldsymbol{F} = m\,\boldsymbol{a}$, where m is mass (item 4-1) and $\boldsymbol{a}$ is acceleration (ISO 80000-3:2006, item 3-9.1).
4-9.2 (*3-9.2*)	weight *fr poids* (m)	$\boldsymbol{F}_{\mathrm{g}}$, $\boldsymbol{Q}$	$\boldsymbol{F}_{\mathrm{g}} = m\,\boldsymbol{g}$ where m is mass (item 4-1) and $\boldsymbol{g}$ is local acceleration of free fall (ISO 80000-3:2006, item 3-9.2)	It should be noted that, when the reference frame is Earth, this quantity comprises not only the local gravitational force but also the local centrifugal force due to the rotation of the Earth. The effect of atmospheric buoyancy is excluded in the weight. [See Comptes rendus, 3rd CGPM (1901), p. 70.] In common parlance, the name "weight" continues to be used where "mass" is meant, but this practice is deprecated.
4-10 (*3-14*)	gravitational constant *fr constante* (f) *de gravitation*	G	$F = G\,m_1 m_2/r^2$ where F is the gravitational force between two particles (item 4-9.1), m_1 and m_2 are the masses of the two particles (item 4-1) and r is the distance between the two particles (ISO 80000-3:2006, item 3-1.9)	$G = 6{,}674\,2(10) \times 10^{-11}$ $\mathrm{N{\cdot}m^2/kg^2}$ [2002 CODATA recommended values][a]
4-11 (*3-10*)	impulse *fr impulsion* (f)	$\boldsymbol{I}$	$\boldsymbol{I} = \int \boldsymbol{F}\mathrm{d}t$ where $\boldsymbol{F}$ is force (item 4-9.1) and t is time (ISO 80000-3:2006, item 3-7)	For a time interval $[t_1, t_2]$, $\boldsymbol{I}(t_1, t_2) = \boldsymbol{p}(t_2) - \boldsymbol{p}(t_1) = \Delta\boldsymbol{p}$

[a] Mohr P.J. and Taylor B.N. 2002 CODATA recommended values of the fundamental physical constants, *Rev. Mod. Phys.*, **77** (1), 2005, pp. 1-107.

UNITS				MECHANICS
Item No.	Name	International symbol	Definition	Conversion factors and remarks
4-8.a	kilogram metre per second	kg·m/s		
4-9.a	newton	N	1 N := 1 kg·m/s^2	
4-10.a	newton metre squared per kilogram squared	N·m^2/kg^2		
4-11.a	newton second	N·s		

(*continued*)