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Quantities and units of mechanics

Grandeurs et unités de mécanique

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up 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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 31/III was developed by Technical Committee ISO/TC 12, *Quantities, units, symbols, conversion factors and conversion tables*, and was circulated to the member bodies in October 1975.

It has been approved by the member bodies of the following countries :

Austria	Hungary	South Africa, Rep. of
Belgium	India	Sri Lanka
Brazil	Israel	Sweden
Canada	Mexico	Turkey
Czechoslovakia	Netherlands	United Kingdom
Denmark	Norway	U.S.A.
Finland	Pakistan	Yugoslavia
France	Poland	
Germany	Portugal	

The member bodies of the following countries expressed disapproval of the document on technical grounds :

Japan*
Switzerland
U.S.S.R.

* Disagreement concerning the decimal marker only.

This International Standard cancels and replaces ISO Recommendation R 31/III-1960, of which it constitutes a technical revision.

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Quantities and units of mechanics

INTRODUCTION

This document, containing a table of *quantities and units of mechanics*, is part III of ISO 31, which deals with quantities and units in the various fields of science and technology. The complete list of parts of ISO 31 is as follows :

Part 0 : *General introduction — General principles concerning quantities, units and symbols.*

Part I : *Quantities and units of space and time.*

Part II : *Quantities and units of periodic and related phenomena.*

Part III : *Quantities and units of mechanics.*

Part IV : *Quantities and units of heat.*

Part V : *Quantities and units of electricity and magnetism.*

Part VI : *Quantities and units of light and related electromagnetic radiations.*

Part VII : *Quantities and units of acoustics.*

Part VIII : *Quantities and units of physical chemistry and molecular physics.*

Part IX : *Quantities and units of atomic and nuclear physics.*

Part X : *Quantities and units of nuclear reactions and ionizing radiations.*

Part XI : *Mathematical signs and symbols for use in the physical sciences and technology.*

Part XII : *Dimensionless parameters.*

Part XIII : *Quantities and units of solid state physics.*

Arrangement of the tables

The tables of quantities and units in ISO 31 are arranged so that the quantities are presented on left-hand pages and the units on corresponding right-hand pages.

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

Where the numbering of the items 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.

Tables of quantities

The most important quantities within the field of this document are given together with their symbols and, in most cases, definitions. These definitions are given merely for identification; they are not intended to be complete.

The vectorial character of some quantities is pointed out, especially when this is needed for the definitions, but no attempt is made to be complete or consistent.

In most cases only one symbol for the quantity is given[1]; where two or more symbols are given for one quantity and no special distinction is made, they are on an equal footing.

Tables of units

Units for the corresponding quantities are given together with the international symbols and the definitions. For further information, see also part 0.

The units are arranged in the following way :

1) The names of the SI units are given in large print (larger than text size). The SI units and their decimal multiples and sub-multiples formed by means of the SI prefixes are particularly recommended. The decimal multiples and sub-multiples are not explicity mentioned.

2) The names of non-SI units which may be used together with SI units because of their practical importance or because of their use in specialized fields are given in normal print (text size).

3) The names of non-SI units which may be used temporarily together with SI units are given in small print (smaller than text size).

The units in classes 2 and 3 are separated by a broken line from the SI units for the quantities concerned.

1) When two types of sloping letters exist (for example as with ϑ, θ; φ, ϕ; and g, g) only one of these is given. This does not mean that the other is not equally acceptable.

4) Non-SI units which should not be used together with SI units are given in annexes in some parts of ISO 31. The annexes are not integral parts of the standards. They are arranged in three groups :

a) *Units of the CGS-system with special names*

It is generally preferable not to use CGS-units with special names and symbols together with SI units.

b) *Units based on the foot, pound and second and some other units*

c) *Other units*

These are given for information, especially regarding the conversion factor. The use of those units marked with † is deprecated.

Remark on supplementary units

The Conférence générale des poids et mesures (CGPM : General Conference for Weights and Measures) has classified the SI units, radian and steradian, as "supplementary units", deliberately leaving open the question of whether they are base units or derived units, and consequently the question of whether angle and solid angle are to be considered as base quantities or derived quantities.

In ISO 31, plane angle and solid angle are treated as derived quantities (see also part 0). They are defined in ISO 31 as ratios of two lengths and of two areas respectively, and consequently they are treated as dimensionless quantities. Although in this treatment the coherent unit for both quantities is the number 1, it is convenient to use the special names radian and steradian instead of the number 1 in many practical cases.

If plane angle and solid angle were treated as base quantities, the units radian and steradian would be base units and could not be considered as special names for the number 1. Such a treatment would require extensive changes in ISO 31.

Number of digits in numerical statements[1)]

All numbers in the column "Definition" are exact.

In the column "Conversion factors", the conversion factors on which the calculation of others are based are normally given to seven significant digits. When they are exact and contain seven or fewer digits and where it is not obvious from the context, the word "exactly" is added, but when they can be terminated after more than seven digits, they may be given in full. When the conversion factors are derived from experiment, they are given with the number of significant digits justified by the accuracy of the experiments. Generally, this means that in such cases the last digit only is in doubt. When, however, experiment justifies more than seven digits, the factor is usually rounded off to seven significant digits.

The other conversion factors are given to not more than six significant digits; when they are exactly known and contain six or fewer digits and where it is not obvious from the context, the word "exactly" is added.

Numbers in the column "Remarks" are given to a precision appropriate to the particular case.

1) The decimal sign is a comma on the line. In documents in the English language, a comma or a dot on the line may be used.

3. Mechanics

Quantities
3-1.1 . . . 3-8.1

Item No.	Quantity	Symbol	Definition	Remarks
3-1.1	mass	m		
3-2.1	density (mass density)	ϱ	Mass divided by volume	
3-3.1	relative density	d	Ratio of the density of a substance to the density of a reference substance under conditions that should be specified for both substances	This quantity is dimensionless
3-4.1	specific volume	v	Volume divided by mass	
3-5.1 —	linear density	ϱ_l	Mass divided by length	
3-6.1 —	surface density	ϱ_A, (ϱ_S)	Mass divided by area	
3-7.1 (3-5.1)	momentum	p	Product of mass and velocity	
3-8.1 (3-6.1)	moment of momentum, angular momentum	L	The moment of momentum of a particle about a point is equal to the vector product of the radius vector from this point to the particle and the momentum of the particle	

3. Mechanics

Units
3-1.a . . . 3-8.a

Item No.	Name of unit	International symbol for unit	Definition	Conversion factors	Remarks
3-1.a	kilogram	kg	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) NOTE – Names of decimal multiples and sub-multiples of the unit of mass are formed by attaching prefixes to the word "gram" (CIPM (1967)). $1\ g = 10^{-3}\ kg$
3-1.b	tonne	t	$1\ t = 1\ 000\ kg$		Also called in English metric ton
3-2.a	kilogram per cubic metre	kg/m^3			
3-2.b	tonne per cubic metre	t/m^3		$1\ t/m^3 = 1\ 000\ kg/m^3 = 1\ g/cm^3$	Also called in English metric ton per cubic metre
3-2.c	kilogram per litre	kg/l		$1\ kg/l = 1\ 000\ kg/m^3 = 1\ g/cm^3$	
3-4.a	cubic metre per kilogram	m^3/kg			
3-5.a	kilogram per metre	kg/m			The unit tex is used for textile filaments; $1\ tex = 10^{-6}\ kg/m = 1\ g/km$
3-6.a	kilogram per square metre	kg/m^2			
3-7.a	kilogram metre per second	kg·m/s			
3-8.a	kilogram metre squared per second	$kg·m^2/s$			

Quantities
3-9.1 . . . 3-11.1

3. Mechanics (continued)

Item No.	Quantity	Symbol	Definition	Remarks
3-9.1 (3-7.1)	moment of inertia (dynamic moment of inertia)	I, J	The (dynamic) moment of inertia of a body about an axis is the sum (integral) of the products of its mass-elements and the squares of their distances from the axis	To be distinguished from 3-18.1 and 3-18.2
3-10.1 (3-8.1)	force	F	The resultant force acting on a body is equal to the rate of change of the momentum of the body	
3-10.2 (3-8.2)	weight	$G, (P, W)$	The weight of a body in a specified reference system is that force which, when applied to the body, would give it an acceleration equal to the local acceleration of free fall in that reference system	When the reference system is the earth, the quantity here defined has commonly been called the local force of gravity on the body. It is noteworthy that the "weight" arises not only from the resultant of the gravitational forces existing at the place where the body is, but also from the local centrifugal force The effect of atmospheric buoyancy is excluded, and consequently the weight defined is the weight in vacuo. (See also Comptes Rendus, 3eme Conférence Générale des Poids et Mesures, 1901, p. 70) In common parlance, the word "weight" is often used to mean mass
3-11.1 —	gravitational constant	$G, (f)$	The gravitational force between two particles is $F = G\frac{m_1 m_2}{r^2}$ where r is the distance between the particles, and m_1 and m_2 are their masses	$G = (6{,}672\,0 \pm 0{,}004\,1)\ 10^{-11}$ $N \cdot m^2/kg^2$ *

* CODATA Bulletin 11 (1973).

3. Mechanics (continued)

Item No.	Name of unit	International symbol for unit	Definition	Conversion factors	Remarks
3-9.a	kilogram metresquared	$kg \cdot m^2$			
3-10.a	newton	N	1 N is that force which, when applied to a body having a mass of 1 kg, gives it an acceleration of 1 m/s^2		
3-11.a	newton square metre per kilogram squared	$N \cdot m^2/kg^2$			

Quantities
3-12.1 . . . 3-13.3

3. Mechanics (continued)

Item No.	Quantity	Symbol	Definition	Remarks
3-12.1 (3-10.1)	moment of force	M	The moment of a force about a point is equal to the vector product of the radius vector, from this point to any point on the line of action of the force, and the force	In elasticity, M is used for bending moment and T for twisting or torsional moment
3-12.2 (3-10.3)	torque, moment of a couple	T		
3-13.1 (3-11.1)	pressure	p	Force divided by area	The symbol p_e is recommended for gauge pressure, defined as $p - p_{amb}$, where p_{amb} is the ambient pressure. The numerical value of a gauge pressure is positive or negative according as p is larger or smaller than p_{amb} respectively
3-13.2 (3-11.2)	normal stress	σ		
3-13.3 (3-11.3)	shear stress	τ		

3. Mechanics (continued)

Item No.	Name of unit	International symbol for unit	Definition	Conversion factors	Remarks
3-12.a	newton metre	N·m			The symbol for this unit should be written in such a way that it could not be confused with the symbol for millinewton
3-13.a	pascal	Pa	1 Pa = 1 N/m²		
3-13.b	bar	bar	1 bar = 10^5 Pa	1 bar = 10^5 Pa (exactly)	1 bar = 100 kPa = 0,1 MPa The use of the bar should be restricted to the field of fluid pressure.
3-13.c	standard atmosphere	atm	1 atm = 101 325 Pa	1 atm = 101 325 Pa (exactly)	Definition adopted by the 10th Conférence générale des poids et mesures (1954)