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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www. iso. org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www. iso .org/iso/foreword. html.

This document was prepared by Technical Committee ISO/TC 12, *Quantities and units*, in collaboration with Technical Committee IEC/TC 25, *Quantities and units*.

This second edition cancels and replaces the first edition (ISO 80000-4:2006), which has been technically revised.

The main changes compared to the previous edition are as follows:

— the table giving the quantities and units has been simplified;

— some definitions and the remarks have been stated physically more precisely.

A list of all parts in the ISO 80000 and IEC 80000 series can be found on the ISO and IEC websites.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Quantities and units —

Part 4:
Mechanics

1 Scope

This document gives names, symbols, definitions and units for quantities of mechanics. Where appropriate, conversion factors are also given.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

Names, symbols, definitions and units for quantities used in mechanics are given in Table 1.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

Table 1 — Quantities and units used in mechanics

Item No.	Quantity			Unit	Remarks
	Name	Symbol	Definition		
4-1	mass	m	property of a body which expresses itself in terms of inertia with regard to changes in its state of motion as well as its gravitational attraction to other bodies	kg	The kilogram (kg) is one of the seven base units (see ISO 80000-1) of the International System of Units, the SI. See also IEC 60050-113.
4-2	mass density, density	ρ, ρ_m	quantity representing the spatial distribution of mass of a continuous material: $\rho(\boldsymbol{r})=\frac{\mathrm{d}m}{\mathrm{d}V}$ where m is mass of the material contained in an infinitesimal domain at point $\boldsymbol{r}$ and V is volume of this domain	kg m^{-3}	
4-3	specific volume	v	reciprocal of mass density ρ (item 4-2): $v=\frac{1}{\rho}$	kg^{-1} m^3	
4-4	relative mass density, relative density	d	quotient of mass density of a substance ρ and mass density of a reference substance ρ_0 : $d=\frac{\rho}{\rho_0}$	1	Conditions and material should be specified for the reference substance.
4-5	surface mass density, surface density	ρ_A	quantity representing the areal distribution of mass of a continuous material: $\rho_A(\boldsymbol{r})=\frac{\mathrm{d}m}{\mathrm{d}A}$ where m is the mass of the material at position $\boldsymbol{r}$ and A is area	kg m^{-2}	The name "grammage" should not be used for this quantity.

Table 1 *(continued)*

Item No.	Quantity			Unit	Remarks
	Name	Symbol	Definition		
4-6	linear mass density, linear density	ρ_l	quantity representing the linear distribution of mass of a continuous material: $\rho_l(\boldsymbol{r}) = \frac{\mathrm{d}m}{\mathrm{d}l}$ where *m* is the mass of the material at position $\boldsymbol{r}$ and *l* is length	kg m^{-1}	
4-7	moment of inertia	$\boldsymbol{J}$	tensor (ISO 80000-2) quantity representing rotational inertia of a rigid body relative to a fixed centre of rotation expressed by the tensor product: $\boldsymbol{L} = \boldsymbol{J}\boldsymbol{\omega}$ where $\boldsymbol{L}$ is angular momentum (ISO 80000-3) of the body relative to the reference point and $\boldsymbol{\omega}$ is its angular velocity (ISO 80000-3)	kg m^2	The calculation of the value requires an integration.
4-8	momentum	$\boldsymbol{p}$	product of mass *m* (item 4-1) of a body and velocity $\boldsymbol{v}$ (ISO 80000-3) of its centre of mass: $\boldsymbol{p} = m\boldsymbol{v}$	kg m s^{-1}	
4-9.1	force	$\boldsymbol{F}$	vector (ISO 80000-2) quantity describing interaction between bodies or particles	N kg m s^{-2}	
4-9.2	weight	$\boldsymbol{F}_\mathrm{g}$	force (item 4-9.1) acting on a body in the gravitational field of Earth: $\boldsymbol{F}_\mathrm{g} = m\boldsymbol{g}$ where *m* (item 4-1) is the mass of the body and $\boldsymbol{g}$ is the local acceleration of free fall (ISO 80000-3)	N kg m s^{-2}	In colloquial language, the name "weight" continues to be used where "mass" is meant. This practice should be avoided. Weight is an example of a gravitational force. Weight comprises not only the local gravitational force but also the local centrifugal force due to the rotation of the Earth.
4-9.3	static friction force, static friction	$\boldsymbol{F}_\mathrm{s}$	force (item 4-9.1) resisting the motion before a body starts to slide on a surface	N kg m s^{-2}	For the static friction coefficient, see item 4-23.1.
4-9.4	kinetic friction force, dynamic friction force	$\boldsymbol{F}_\mu$	force (item 4-9.1) resisting the motion when a body slides on a surface	N kg m s^{-2}	For the kinetic friction factor, see item 4-23.2.

Table 1 *(continued)*

Item No.	Quantity			Unit	Remarks
	Name	Symbol	Definition		
4-9.5	rolling resistance, rolling drag, rolling friction force	$\boldsymbol{F}_{\mathrm{rr}}$	force (item 4-9.1) resisting the motion when a body rolls on a surface	N kg m s^{-2}	For the rolling resistance factor, see item 4-23.3.
4-9.6	drag force	$\boldsymbol{F}_{\mathrm{D}}$	force (item 4-9.1) resisting the motion of a body in a fluid	N kg m s^{-2}	For the drag coefficient, see item 4-23.4.
4-10	impulse	$\boldsymbol{I}$	vector (ISO 80000-2) quantity describing the effect of force acting during a time interval: $\boldsymbol{I} = \int_{t_1}^{t_2} \boldsymbol{F} \mathrm{d}t$ where $\boldsymbol{F}$ is force (item 4-9.1), t is time (ISO 80000-3) and $[t_1, t_2]$ is considered time interval	N s kg m s^{-1}	For a time interval $[t_1, t_2]$, $\boldsymbol{I}(t_1, t_2) = \boldsymbol{p}(t_1) - \boldsymbol{p}(t_2) = \Delta \boldsymbol{p}$ where $\boldsymbol{p}$ is momentum (item 4-8).
4-11	angular momentum	$\boldsymbol{L}$	vector (ISO 80000-2) quantity described by the vector product: $\boldsymbol{L} = \boldsymbol{r} \times \boldsymbol{p}$ where $\boldsymbol{r}$ is position vector (ISO 80000-3) with respect to the axis of rotation and $\boldsymbol{p}$ is momentum (item 4-8)	kg m^2 s^{-1}	
4-12.1	moment of force	$\boldsymbol{M}$	vector (ISO 80000-2) quantity described by the vector product: $\boldsymbol{M} = \boldsymbol{r} \times \boldsymbol{F}$ where $\boldsymbol{r}$ is position vector (ISO 80000-3) with respect to the axis of rotation and $\boldsymbol{F}$ is force (item 4-9.1)	N m kg m^2 s^{-2}	The bending moment of force is denoted by $\boldsymbol{M}_{\mathrm{b}}$.
4-12.2	torque	T, M_{Q}	quantity described by the scalar product: $T = \boldsymbol{M} \cdot \boldsymbol{e}_{\mathrm{Q}}$ where $\boldsymbol{M}$ is moment of force (item 4-12.1) and $\boldsymbol{e}_{\mathrm{Q}}$ is unit vector of direction with respect to which the torque is considered	N m kg m^2 s^{-2}	For example, torque is the twisting moment of force with respect to the longitudinal axis of a beam or shaft.

Table 1 *(continued)*

Item No.	Quantity			Unit	Remarks
	Name	Symbol	Definition		
4-13	angular impulse	$\boldsymbol{H}$	vector (ISO 80000-2) quantity describing the effect of moment of force during a time interval: $\boldsymbol{H}(t_1;t_2)=\int_{t_1}^{t_2}\boldsymbol{M}\mathrm{d}t$ where $\boldsymbol{M}$ is moment of force (item 4-12.1), t is time (ISO 80000-3) and $[t_1, t_2]$ is considered time interval	N m s kg m^2 s^{-1}	For a time interval $[t_1, t_2]$, $\boldsymbol{H}(t_1,t_2)=\boldsymbol{L}(t_2)-\boldsymbol{L}(t_1)=\Delta\boldsymbol{L}$ where $\boldsymbol{L}$ is angular momentum.
4-14.1	pressure	p	quotient of the component of a force normal to a surface and its area: $p=\frac{\boldsymbol{e}_n\boldsymbol{F}}{A}$ where $\boldsymbol{e}_n$ is unit vector of the surface normal, $\boldsymbol{F}$ is force (item 4-9.1) and A is area (ISO 80000-3)	Pa N m^{-2} kg m^{-1} s^{-2}	
4-14.2	gauge pressure	p_e	pressure p (item 4-14.1) decremented by ambient pressure p_{amb}: $p_e=p-p_{amb}$	Pa N m^{-2} kg m^{-1} s^{-2}	Often, p_{amb} is chosen as a standard pressure. Gauge pressure is positive or negative.
4-15	stress	σ	tensor (ISO 80000-2) quantity representing state of tension of matter	Pa N m^{-2} kg m^{-1} s^{-2}	Stress tensor is symmetric and has three normal-stress and three shear-stress (Cartesian) components.
4-16.1	normal stress	σ_n, σ	scalar (ISO 80000-2) quantity describing surface action of a force into a body equal to: $\sigma_n=\frac{\mathrm{d}F_n}{\mathrm{d}A}$ where F_n is the normal component of force (item 4-9.1) and A is the area (ISO 80000-3) of the surface element	Pa N m^{-2} kg m^{-1} s^{-2}	A couple of mutually opposite forces of magnitude F acting on the opposite surfaces of a slice (layer) of homogenous solid matter normal to it, and evenly distributed, cause a constant normal stress $\sigma_n=FA$ in the slice (layer).

Table 1 *(continued)*

Item No.	Quantity			Unit	Remarks
	Name	Symbol	Definition		
4-16.2	shear stress	τ_s, τ	scalar (ISO 80000-2) quantity describing surface action of a force into a body equal to: $\tau_s = \frac{dF_t}{dA}$ where F_t is the tangential component of force (item 4-9.1) and A is the area (ISO 80000-3) of the surface element	Pa N m^{-2} kg m^{-1} s^{-2}	A couple of mutually opposite forces of magnitude F acting on the opposite surfaces of a slice (layer) of homogenous solid matter parallel to it, and evenly distributed, cause a constant shear stress $\tau = F/A$ in the slice (layer).
4-17.1	strain	ε	tensor (ISO 80000-2) quantity representing the deformation of matter caused by stress	1	Strain tensor is symmetric and has three linear-strain and three shear strain (Cartesian) components.
4-17.2	relative linear strain	ε, (e)	quotient of change in length Δl (ISO 80000-3) of an object and its length l (ISO 80000-3): $\varepsilon = \frac{\Delta l}{l}$	1	
4-17.3	shear strain	γ	quotient of parallel displacement Δx (ISO 80000-3) of two surfaces of a layer and the thickness d (ISO 80000-3) of the layer: $\gamma = \frac{\Delta x}{d}$	1	
4-17.4	relative volume strain	ϑ	quotient of change in volume ΔV (ISO 80000-3) of an object and its volume V_0 (ISO 80000-3): $\vartheta = \frac{\Delta V}{V_0}$	1	
4-18	Poisson number	μ, (ν)	quotient of change in width Δb (width is defined in ISO 80000-3) and change in length Δl (length is defined in ISO 80000-3) of an object: $\mu = \frac{\Delta b}{\Delta l}$	1	

Table 1 *(continued)*

Item No.	Quantity			Unit	Remarks
	Name	Symbol	Definition		
4-19.1	modulus of elasticity, Young modulus	E, E_m, Y	quotient of normal stress σ (item 4-16.1) and relative linear strain ε (item 4-17.2): $E = \frac{\sigma}{\varepsilon}$	Pa N m^{-2} kg m^{-1} s^{-2}	Conditions should be specified (e.g. adiabatic or isothermal process).
4-19.2	modulus of rigidity, shear modulus	G	quotient of shear stress τ (item 4-16.2) and shear strain γ (item 4-17.3): $G = \frac{\tau}{\gamma}$	Pa N m^{-2} kg m^{-1} s^{-2}	Conditions should be specified (e.g. isentropic or isothermal process).
4-19.3	modulus of compression, bulk modulus	K, K_m, B	negative of the quotient of pressure p (item 4-14.1) and relative volume strain ϑ (item 4-17.4): $K = -\frac{p}{\vartheta}$	Pa N m^{-2} kg m^{-1} s^{-2}	Conditions should be specified (e.g. isentropic or isothermal process).
4-20	compressibility	$\varkappa$	negative relative change of volume V (ISO 80000-3) of an object under pressure p (item 4-14.1) expressed by: $\varkappa = -\frac{1}{V}\frac{dV}{dp}$	Pa^{-1} kg^{-1} m s^2	Conditions should be specified (e.g. isentropic or isothermal process). See also ISO 80000-5.
4-21.1	second axial moment of area	I_a	geometrical characteristic of a shape of a body equal to: $I_a = \iint_M r_Q^2 dA$ where M is the two-dimensional domain of the cross-section of a plane and considered body, r_Q is radial distance (ISO 80000-3) from a Q-axis in the plane of the surface considered and A is area (ISO 80000-3)	m^4	This quantity is often referred to wrongly as "moment of inertia" (item 4-7). The subscript, a, may be omitted when there is no risk of confusion.

Table 1 *(continued)*

Item No.	Quantity			Unit	Remarks
	Name	Symbol	Definition		
4-21.2	second polar moment of area	I_p	geometrical characteristic of a shape of a body equal to: $I_p = \iint_M r_Q^2 dA$ where M is the two-dimensional domain of the cross-section of a plane and considered body, r_Q is radial distance (ISO 80000-3) from a Q-axis perpendicular to the plane of the surface considered and A is area (ISO 80000-3)	m^4	This quantity is often referred to wrongly as “moment of inertia” (item 4-7). The subscript, p, may be omitted when there is no risk of confusion.
4-22	section modulus	Z, (W)	geometrical characteristic of a shape of a body equal to: $Z = I_a / r_{Q,max}$ where I_a is the second axial moment of area (item 4-21.1) and $r_{Q,max}$ is the maximum radial distance (ISO 80000-3) of any point in the surface considered from the Q-axis with respect to which I_a is defined	m^3	
4-23.1	static friction coefficient, static friction factor, coefficient of static friction	μ_s, (f_s)	proportionality factor between the maximum magnitude of the tangential component F_{max} of the static friction force (item 4-9.3) and the magnitude of the normal component N of the contact force (item 4-9.1) between two bodies at relative rest with respect to each other: $F_{max} = \mu_s N$	1	When it is not necessary to distinguish between dynamic friction factor and static friction factor, the name friction factor may be used for both.
4-23.2	kinetic friction factor, dynamic friction factor	μ, (f)	proportionality factor between the magnitudes of the kinetic friction force, F_μ (item 4-9.4) and the normal component N of the contact force (item 4-9.1): $F_\mu = \mu N$	1	When it is not necessary to distinguish between dynamic friction factor and static friction factor, the name friction factor may be used for both. The dynamic friction factor μ is independent in first approximation of the contact surface.

Table 1 *(continued)*

Item No.	Quantity			Unit	Remarks
	Name	Symbol	Definition		
4-23.3	rolling resistance factor	C_{rr}	proportionality factor between the magnitude of the tangential component *F* and the magnitude of the normal component *N* of the force applied to a body rolling on a surface at constant speed: $F = C_{rr} N$	1	Also known as rolling resistance coefficient, RRC.
4-23.4	drag coefficient, drag factor	C_D	factor proportional to magnitude F_D of the drag force (item 4-9.6) of a body moving in a fluid, dependent on the shape and speed v (ISO 80000-3) of a body: $F_D = \frac{1}{2} C_D \rho v^2 A$ where ρ is mass density (item 4-2) of the fluid and *A* is cross-section area (ISO 80000-3) of the body	1	
4-24	dynamic viscosity, (viscosity)	η	for laminar flows, proportionality constant between shear stress τ_{xz} (item 4-16.2) in a fluid moving with a velocity v_x (ISO 80000-3) and gradient $\mathrm{d}v_x/\mathrm{d}z$ perpendicular to the plane of shear: $\tau_{xz} = \eta \frac{\mathrm{d}v_x}{\mathrm{d}z}$	Pa s kg m^{-1} s^{-1}	
4-25	kinematic viscosity	ν	quotient of dynamic viscosity η (item 4-24) and mass density ρ (item 4-2) of a fluid: $\nu = \frac{\eta}{\rho}$	m^2 s^{-1}	
4-26	surface tension	γ, σ	magnitude of a force acting against the enlargement of area portion of a surface separating a liquid from its surrounding	N m^{-1} kg s^{-2}	The concept of surface energy is closely related to surface tension and has the same dimension.

Table 1 *(continued)*

Item No.	Quantity			Unit	Remarks
	Name	Symbol	Definition		
4-27	power <mechanics>	P	scalar product of force $\boldsymbol{F}$ (item 4-9.1) acting to a body and its velocity $\boldsymbol{v}$ (ISO 80000-3): $P = \boldsymbol{F}\boldsymbol{v}$	W N m s^{-1} kg m^2 s^{-3}	
4-28.1	potential energy	V, E_p	for conservative force $\boldsymbol{F}$, scalar additive quantity obeying condition $\boldsymbol{F} = -\nabla F$, if it exists	J kg m^2 s^{-2}	For the definition of energy, see ISO 80000-5. A force is conservative when the force field is irrotational, i.e. $\mathbf{rot}\boldsymbol{F} = 0$, or $\boldsymbol{F}$ is perpendicular to the speed of the body to ensure $\boldsymbol{F} \cdot \mathrm{d}\boldsymbol{r} = 0$.
4-28.2	kinetic energy	T, E_k	scalar (ISO 80000-2) quantity characterizing a moving body expressed by: $T = \frac{1}{2} m v^2$ where m is mass (item 4-1) of the body and v is its speed (ISO 80000-3)	J kg m^2 s^{-2}	For the definition of energy, see ISO 80000-5.
4-28.3	mechanical energy	E, W	sum of kinetic energy T (item 4-28.2) and potential energy V (item 4-28.1): $E = T + V$	J kg m^2 s^{-2}	The symbols E and W are also used for other kinds of energy. This definition is understood in a classical way and it does not include thermal motion.
4-28.4	mechanical work, work	A, W	process quantity describing the total action of a force $\boldsymbol{F}$ (item 4-9.1) along a continuous curve Γ in three-dimensional space with infinitesimal displacement (ISO 80000-3) d$\boldsymbol{r}$, as a line integral of their scalar product: $A = \int_{\Gamma} \boldsymbol{F} \cdot \mathrm{d}\boldsymbol{r}$	J kg m^2 s^{-2}	The definition covers the case $A = -\int_{\Gamma} p \cdot \mathrm{d}V$ where Γ is a curve in the phase space and implies that work generally depends upon Γ, and that type of process must be defined (e.g. isentropic or isothermic).

Table 1 *(continued)*

Item No.	Quantity			Unit	Remarks
	Name	Symbol	Definition		
4-29	efficiency <mechanics>	η	quotient of output power P_{out} (item 4-27) from a system and input power P_{in} (item 4-27) to this system: $\eta = \frac{P_{\text{out}}}{P_{\text{in}}}$	1	The system must be specified. This quantity is often expressed by the unit percent, symbol %.
4-30.1	mass flow	$\boldsymbol{j}_m$	vector (ISO 80000-2) quantity characterizing a flowing fluid by the product of its local mass density ρ (item 4-2) and local velocity $\boldsymbol{v}$ (ISO 80000-3): $\boldsymbol{j}_m = \rho \boldsymbol{v}$	kg m^{-2} s^{-1}	
4-30.2	mass flow rate	q_m	scalar (ISO 80000-2) quantity characterizing the total flow through the two-dimensional domain A with normal vector $\boldsymbol{e}_{\text{n}}$ of a flowing fluid with mass flow $\boldsymbol{j}_m$ (item 4-30.1) as an integral: $q_m = \iint_A \boldsymbol{j}_m \cdot \boldsymbol{e}_{\text{n}} \mathrm{d}A$ where dA is the area (ISO 80000-3) of an element of the two-dimensional domain A	kg s^{-1}	
4-30.3	mass change rate	q_m	rate of increment of mass m (item 4-1): $q_m = \frac{\mathrm{d}m}{\mathrm{d}t}$ where dm is the infinitesimal mass (item 4-1) increment and dt is the infinitesimal duration (ISO 80000-3)	kg s^{-1}	

Table 1 *(continued)*

Item No.	Quantity			Unit	Remarks
	Name	Symbol	Definition		
4-31	volume flow rate	q_V	scalar (ISO 80000-2) quantity characterizing the total flow through the two-dimensional domain A with the normal vector $\boldsymbol{e}_\mathrm{n}$ of a flowing fluid with velocity $\boldsymbol{v}$ (ISO 80000-3) as an integral: $q_V = \iint_A \boldsymbol{v} \cdot \boldsymbol{e}_\mathrm{n} \, \mathrm{d}A$ where $\mathrm{d}A$ is the area (ISO 80000-3) of an element of the two-dimensional domain A	$\mathrm{m^3\ s^{-1}}$	
4-32	action	S	time integral of energy E over a time interval (t_1, t_2): $S = \int_{t_1}^{t_2} E \, \mathrm{d}t$	J s $\mathrm{kg\ m^2\ s^{-1}}$	The energy may be expressed by a Lagrangian or Hamiltonian function.