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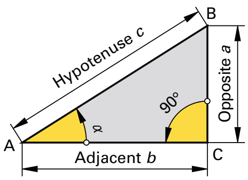

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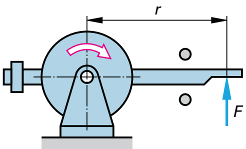

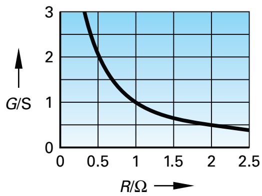

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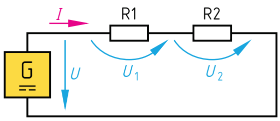

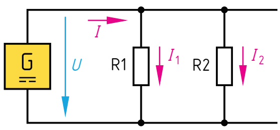

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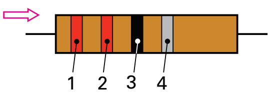

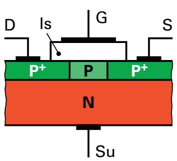

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Symbol	Meaning
Lowercase letters	
a	1. acceleration 2. transformer ratio
c	1. spec. thermal capacity 2. electrochemical equivalent 3. propagation velocity of waves 4. coefficient
d	1. diameter 2. distance 3. dissipation factor 4. duty cycle
e	elementary charge
f	1. frequency 2. filter factor
g	acceleration of free fall, local gravity
h	height
i	1. time-controlled current 2. transmission ratio
j	jerk
l	1. length 2. spacing, distance
m	1. mass 2. number of strands
n	1. speed, rotational frequency 2. integer 1, 2, 3, ... 3. refractive index
o	overdrive factor
p	1. number of pole pairs 2. pressure 3. percentage
r	1. radius 2. rate 3. differential resistance
s	1. shunt current ratio 2. section 3. thickness 4. normalized slip 5. correction 6. sensitivity
t	time
v	1. time-controlled voltage 2. velocity
w	1. width 2. energy density 3. reference variable
x	controlled variable
y	manipulated variable
z	integer, e. g. number of teeth of a gear

Symbol	Meaning
Capital letter	
A	1. area 2. attenuation ratio 3. cross section
B	1. magn. flux density 2. direct current ratio 3. number base
C	1. capacitance 2. thermal capacity 3. constant 4. capital
D	1. deflection coefficient 2. electric flux density 3. attenuation factor 4. spring constant
E	1. electric field strength 2. illuminance
F	1. force 2. factor 3. fault
G	1. conductance 2. amplification factor 3. gravitational force
H	magnetic field strength
I	1. electric current 2. light intensity
J	1. current density 2. moment of inertia
L	1. inductance 2. level
M	1. moment of force 2. memory capacity
N	number of turns
P	active or effective power
Q	1. electric charge 2. heat 3. reactive power 4. quality factor
R	1. active resistance 2. spring rate 3. regidity
S	1. susceptance (band-width) 2. apparent power 3. steepness 4. slip (absolute) 5. transmission quantity
T	1. cycle duration 2. transmission factor 3. temperature in K
THD	total harmonic distortion
U	voltage
V	1. volume 2. amplification factor
W	1. work 2. energy
X	reactance
Y	apparent admittance
Z	1. impedance 2. wave impedance 3. oscillation impedance

Symbol	Meaning
Greek lowercase letters	
α (alpha)	1. angle 2. temperature coefficient 3. firing angle
β (beta)	1. angle 2. short-circuit current amplification factor
γ (gamma)	1. angle 2. conductivity
δ (delta)	loss angle
ε (epsilon)	permittivity
ε_0	electric constant
ζ (zeta)	work ratio, utilisation ratio
η (eta)	efficiency
λ (lamb-da)	1. wavelength 2. power factor
μ (mü)	1. permeability 2. friction coefficient
μ_0	magnetic constant
ν (nü)	ordinal number
π (pi)	number 3.1415926...
σ (sigma)	1. leakage factor 2. stress
τ (tau)	time constant
φ (phi)	angle, particularly phase-shift angle
ϑ (theta)	temperature in °C
$\varkappa$ (kappa)	conductivity (optional symbol)
ϱ (rho)	1. specific resistance 2. density
ω (omega)	1. angular velocity 2. angular frequency
Greek capital letters	
Δ (Delta)	difference
Θ (Theta)	current linkage
Σ (Sigma)	sum
Φ (Phi)	1. magnetic flux 2. luminous flux
Ψ (Psi)	electric flux
Ω (Omega)	solid angle

Special symbols are created by adding one or more subscripts or other signs to the symbol.

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Subscript, Symbol	Meaning
Digits, characters	
0	1. idle 2. vacuum 3. reference variable
1	1. input 2. order, sequence
2	1. output 2. order, sequence
3, 4, …	order, sequence
^, e.g. $\hat{u}$	peak value
ˇ, e.g. $\check{u}$	minimum value
^ˇ, e.g. $\hat{\check{u}}$	1. peak-to-peak value 2. oscillation width
′, e.g. u'	1. related to 2. note; 3. derivation
△	delta connection
Y	star connection
Lowercase letters	
a	1. breaking 2. leakage..., 3. dis-charge... 4. armature; 5. actual…
b	1. bit; 2. brake…
c	1. cut-off…; 2. crest 3. comparison 4. centripetal…
d	1. referring to DC; 2. digit; 3. direction of dis-placement; 4. dissipation
des	desired…
e	1. error; 2. evaporation
eff	1. effective 2. effective (active)
f	1. frequency 2. fall, fusion 3. fusion…
h	high, upper
i	1. inner; 3. current…; 4. ideal; 5. DC link…
in	input, ingoing
j	junction
k	kinetic
l	low, lower, loss
lt	left
m	1. magentic; 2. mean 3. measured
max	maximum
mec	mechanical
min	minimum
n	1. nominal… 2. normal… 3. noise…
o	1. output 2. outer 3. oscillator
out	output, outgoing
p	1. parallel; 2. pause; 3. pulse; 4. potential; 5. pressure; 6. power…; 7. pre-
perm	permissible
r rat	1. reactive 2. reception 3. rated… 4. rise 5. resonance 6. remanence
rt	right
s	1. starting/start-up... 2. sustained 3. shunt… 4. serial 5. signal… 6. series 7. specific
s, sc	short-circuit…
st	step
t	1. tripping… 2. test…
th	1. thermal 2. threshold
tot	total
u	voltage…
v	visual
w	1. command variable 2. wave… 3. wind… 4. width
x	1. unknown variable 2. in x-direction
y	1. manipulated variable 2. in y-direction 3. y connection
z	zigzag connection
Capital letter	
A	1. ammeter 2. aerial 3. anode 4. system earthing 5. sampling… 6. area 7. ambient
B	1. breakaway… 2. base 3. system earthing (grid) 4. breakover
C	1. collector; 2. capacitive 3. cycle; 4. cluster 5. coupling; 6. channel 7. charging; 8. cogging… 9. carrier
D	1. drain 2. data 3. discharge
E	1. emitter 2. earth
F	1. forward 2. fault
G	1. gate 2. gravitational force 3. smoothing 4. gain
H	1. hysteresis 2. Hall… 3. height 4. heat sink
K	cathode
L	1. locked… 2. inductive 3. load 4. left 5. maximum permissible touch voltage 6. Lorentz… 7. loop
N	nominal, rated…
O	operating…
PF	positive feedback
R	1. reverse 2. active resistance 3. right 4. red
S	1. nominal… 2. shunt… 3. source 4. switch… 5. sector
T	1. total; 2. threshold 3. transformer… 4. track 5. torque
V	1. voltmeter 2. volume
X	at the x-input
Y	1. at the y-input 2. star connection (Y-con-nection)
Z	1. Zener… 2. permissible
Greek lowercase letters	
α (alpha)	in direction of the angle α
σ (sigma)	leakage
φ (phi)	phase-shift related
Greek capital letters	
Δ (Delta)	difference

Subscripts may be combined, e.g. U_{CE} for collector-emitter voltage. Subscripts that consist of several letters may be reduced to the first letter.

Quantity	Previous symbol	Symbol		Unit, Unit symbol
		Preferred symbol	Reserve symbol	
Current and related quantities				
Rated current	I_N	I_{rat}	I_N	
Nominal current	I_n	I_n or I_{nom}	–	
Sustained short-circuit current	I_{kd}	I_k	I_{SC}	
Maximum aperiodic short-circuit current	I_S	$\hat{I}_k$	$\hat{I}_{SC}$	Ampere, A
Initial periodic short-circuit current	i_S	I_{k0}	I_{SC0}	
Transient current	i	I_k'	I_{SC}'	
Subtransient current	i_S	I_k''	I_{SC}''	
Current load	I'	A	Not applicable	Amperes per metre, A/m
Voltage and related quantities				
Rated voltage	U_N	U_{rat}	U_N	
Nominal voltage	U_n	U_n or U_{nom}		Volt, V
Induced voltage	U_i	U_g	Not applicable	
Open-loop voltage	U_0	U_0		
Power and related quantities				
Rated power	P_N	P_{rat}	P_N	Watt, W
Rated apparent power	S_N	S_{rat}	S_N	Volt-ampere, VA
Nominal power	P_n	P_n or P_{nom}		
Input power	P_1 or P_i	P_{in}		
Output power	P_2 or P_o	P_{out}		Watt, W
Mechanical power	P	P_{mec}	Not applicable	
Power dissipation	P_d	P_t		
Power factor	cos φ	λ (lambda)		One (no unit)
Active factor	–	cos φ		
Torques, moments of force				
Torque, moment of force	M	T	M	
Nominal moment/torque	M_n	T_{nom}	Not applicable	
Rated moment/torque	M_N	T_{rat}	M_{rat}	
Breakdown torque	M_K	T_b	M_b	Newton meter, Nm
Holding torque	M_H	T_H	M_H	
Pull-up torque	M_S	T_u	M_u	
Breakaway torque	M_A	T_l	M_l	

nom = nominal, rat = rated, T = torque, active factor = cosine of fundamental (without harmonics), power factor = relation of active power to apparent power (with harmonics)

Length, area, volume, angle

length *l*	metre (sea mile) (mile) (inch)	m 1 sm = 1,852 m 1 mi = 1,609.344 m 1″ = 25.4 mm
area *A*	square metre	m^2
volume *V*	cubic metre (litre)	m^3 1 l = 1 dm^3 = = 1/1,000 m^3
angle (plane) (see page 20)	radian, RAD (degree, DEG)	rad 1° $= \frac{\pi}{180}$ rad,
solid angle *Ω*	steradian	sr

Time, frequency, velocity, acceleration

time *t*	second (minute) (hour) (day)	s 1 min = 60 s 1 h = 60 min = 3,600 s 1 d = 24 h
frequency *f*	hertz	1 Hz = 1/s
speed, rotational frequency *n*	per second (per minute)	1/s = 60/min
angular frequency *ω*	per second	1/s
velocity *v*	metres per second (knot)	m/s 1 kn = 1 sm/h = 0.5144 m/s 1 km/h $= \frac{1}{3,6}$ m/s
angular velocity *ω*	radians per second	rad/s
acceleration *a*	–	m/s^2
jerk *j*	–	m/s^3

Mechanics

mass *m*	kilogram (carat) (tonne)	kg 1 Kt = 0.2 g 1 t = 1,000 kg
density *ρ*	–	kg/m^3, kg/dm^3
moment of inertia *J*	–	$kg \cdot m^2$
force *F*	newton	1 N = 1 $kg \cdot m/s^2$
torque, moment of force *M*	–	Nm
pulse *p*	newton sec.	1 Ns = 1 kg · m/s
pressure *p*	pascal (bar)	1 Pa = 1 N/m^2 1 bar = 0.1 MPa = 10 N/cm^2
surface pressure *p*, rigidity R_p, R_e, modulus of elasticity *E*	–	N/mm^2
work *W*, energy *E, W*	joule (electron volt)	1 J = 1 Nm = 1 Ws 1 eV = 0.1602 aJ
power *P*	watt	1 W = 1 J/s = 1 Nm/s

Electricity

electric charge *Q*, electric flux *Ψ*	coulomb	1 C = 1 A · 1 s = 1 As
surface charge density *σ*, electric flux density *D*	coulombs per square metre	C/m^2
space charge density *ρ*	coulombs per cubic meter	C/m^3
electr. voltage *U*, electr. potential *φ, V*	volt	1 V = 1 J/C
electr. field strength *E*	volts per metre	1 V/m = 1 N/C
electr. capacitance *C*	farad	1 F = 1 As/V = 1 C/V
current loading *A*	amperes per metre	A/m
permittivity, absolute permittivity *ε*	farads per metre	1 F/m = 1 C/(Vm)
electric current *I*	ampere	1 A = 1 C/s
electric current density *J*	amperes per m^2	A/m^2
electric resistance, active resistance *R*, reactance *X*, impedance *Z*	ohm	1 Ω = 1 V/A
electric effective conductance *G*, susceptance *B*, apparent admittance *Y*	siemens	1 S $= \frac{1}{1\,\Omega}$
specific electric resistance *ρ*	ohmmetre	1 Ωm = 100 Ωcm 1 $\Omega mm^2/m$ = 1 µΩm
electric conductivity *γ*	siemens per metre	1 Sm/mm^2 = 1 MS/m
power *P*	watt	1 W = 1 V · 1 A
reactive power *Q*	(var)	1 var = 1 V · 1 A
apparent power *S*	(VA)	1 VA = 1 V · 1 A
inductance *L*	Henry	1 H = 1 Vs/A
work *W*, energy *E, W*	joule (watt-hour) (electron volt)	1 J = 1 Ws 1 Wh = 3.6 kNm 1 eV = 0.1602 aJ

Magnetism

current linkage *Θ*	ampere	A
magnetic field strength *H*	amperes per metre	A/m
magnetic flux *Φ*	weber	1 Wb = 1 T · 1 m^2 = 1 Vs
magn. flux density *B*, magn. polarisation *J*	Tesla	1 T = 1 Wb/m^2 = 1 Vs/m^2
inductance *L*	henry	1 H = 1 Vs/A
permeability *µ*	henrys per metre	1 H/m = 1 Vs/(Am)
magn. resistance R_m	–	1/H = A/Vs

F

Quantity, symbol	SI unit (other unit)	Unit symbol, unit equation
Electromagnetic radiation (except light)		
radiant energy Q_e	joule	1 J = 1 Nm = 1 Ws
radiant power Φ_e	watt	1 W = 1 J/s
radiant intensity I	watt/sterad.	W/sr
radiance L	–	W/(sr · m²)
irradiance E	–	W/m²
Light, optics		
light intensity I_v	candela	cd
luminance L_v	candelas per m²	cd/m²
luminous flux Φ_v	lumen	lm
luminous efficacy η_v	lumens per watt	lm/W
illuminance E_v	lux	1 lx = 1 lm/m²
optical power of lenses D	– (dioptre)	1/m 1 dpt = 1/m
Heat		
centigrade temperature ϑ	degree centigrade	°C
thermodynamic temperature T	kelvin	K (0 K ≙ –273.15 °C)
temperature difference ΔT	kelvin	K
heat Q, inner energy U	joule	1 J = 1 Ws
heat flow Φ	watt	1 W = 1 J/s
thermal resistance (of components) R_{th}	kelvins per watt	K/W
thermal conductivity λ	–	W/(K · m)
heat transfer coefficient h	–	W/(K · m²)
thermal capacity C, entropy S	joules per kelvin	J/K
specific thermal capacity c	–	J/(kg · K)
Chemistry, molecular physics		
quantity of substance n	mol	mol
molar concentration c	–	mol/m³
molar	–	m³/mol
molality b	–	mol/kg
molar mass M	–	kg/mol
molar thermal capacity c_p, c_v	–	J/(mol · K)
diffusion coefficient D	–	m²/s

Quantity, symbol	SI unit (other unit)	Unit symbol, unit equation
Nuclear reaction, ionising radiation		
activity of a radioactive substance A	bequerel	1 Bq = 1/s
absorbed dose D	gray	1 Gy = 1 J/kg
absorbed dose rate D'	grays per second	Gy/s
dose equivalent H	sievert	1 Sv = 1 J/kg
dose equivalent rate H'	sieverts per second	1 Sv/s = 1 J/(kg · s)
ion dose J	coulombs per kilogram	C/kg
ion dose rate J'	amperes per kilogram	1 A/kg = 1 C/(kg · s)
Acoustics		
sound pressure p	pascal	1 Pa = 1 N/m²
sound particle velocity v	metres per second	m/s
sound velocity (propagation velocity) c_s	metres per second	m/s
volume velocity q	–	1 m³/s = 1 m² · 1 m/s
sound intensity I	–	W/m²
specific sound impedance Z	–	Pa · s/m = Ns/m³
acoustic impedance Z_F	–	N · s/m³
mechanical impedance Z_M	–	N · s/m = kg/s
equivalent absorption area A	square metre	m²
Other disciplines		
distance in astronomy l	(astronomical unit) parsec	1 AE = 149.6 Gm[1] 1 pc = 30.857 Pm[1]
velocity of light c	km/s	c ≈ 300,000 km/s
light year l.y.	km	1 l.y. = 9.461 · 10¹² km
mass in nuclear physics m	(nuclear mass unit)	1 u = 1.66 · 10⁻²⁷ kg
mass per unit length of textile fibres and threads Tt	tex	1 tex = 1 g/km
area of plots of land A	are hectare	1 a = 100 m² 1 ha = 100 a

[1] Unit prefixes G, P see page 18

Symbol	Meaning	Example
General symbols		
$\ldots n$	and so on until n	$k = 1, 2, 3, \ldots, n$
$\ldots$	and so on until infinity	$n = 1, 2, 3, \ldots$
		$\sqrt{2} = 1.41421 \ldots$
Boolean algebra		
$\neg a, \bar{a}$	NOT a	$\overline{a \wedge b} = \neg (a \wedge b)$
$\wedge$	AND	$a \wedge b$ or $\wedge (a, b)$
$\vee$	OR	$a \vee b$ or $\vee (a, b)$
$\overline{\wedge}$	NOT AND (NAND)	$a \,\overline{\wedge}\, b = \overline{a \wedge b}$
$\overline{\vee}$	NOT OR (NOR)	$a \,\overline{\vee}\, b = \overline{a \vee b}$
Set theory		
$\in$	element of	$a \in M$: a is element of M
$\subset$	subset	$M_1 \subset M_2$: M_1 is subset of M_2
$\cup$	union of sets	$\{1, 2\} \cup \{3, 4\} = \{1, 2, 3, 4\}$
$\Rightarrow$	from this follows that	$a \cdot b = c \Rightarrow a = c/b$
Arithmetic		
$=$	equal to	$P = U \cdot I$
$\neq$	not equal, unequal	$4 \neq 5$
$\sim$	proportional	$u \sim r$
$\approx$	approximately	$\pi \approx 3.14$
$\triangleq$	corresponds to	1 cm $\triangleq$ 20 N
$<$	less than	$2 < 3$
$>$	greater than	$5 > 2$
$\leq$	less than or equal to	$a \leq 10$
$\geq$	greater than or equal to	$n \geq 7$
$<<$	considerably less than	$R << 100\ \text{k}\Omega$
$>>$	considerably greater than	$R_x >> R_n$
$\cdot, \times$	times, multiplied	$a \cdot b = ab$, $12 \times 3 = 36$
–, /, :	divided by	$\frac{7}{2} = 7/2 = 7:2$
%	per cent	1 % = 10^{-2}, 50 % = 0,5
‰	per thousand, per mil	1 ‰ = 10^{-3}, 8 ‰ = 0,8 %
( ), [ ], { }, < >	round, squared, curly, pointed brackets	$[a (b - c) + d]^2$
$\lvert z \rvert$	amount of z	$\lvert 4 \rvert = 4$, $\lvert -7 \rvert = 7$
$n!$	n factorial	$n! = 1 \cdot 2 \cdot 3 \cdot \ldots \cdot n$, $3! = 6$
Σ	sum	$\Sigma I = I_1 + I_2 + I_3 + \ldots$
Π	product	$\Pi k = k_1 \cdot k_2 \cdot k_3 \cdot \ldots$
$\sqrt{\ }$	square root of	$\sqrt{16} = 4$
$\sqrt[n]{\ }$	nth root of	$\sqrt[3]{8} = 2$
π	pi	$\pi = 3.14159\ldots$

Symbol	Meaning	Example
∞	infinite	$n = 1, 2, 3, \ldots, \infty$
$\rightarrow$	versus, approaches, exceeds	$x \rightarrow a$, x approaches the value a
$f(x)$	function of x	$f(I) = I^2 \cdot R$
i or j	imaginary unit	$i^2 = j^2 = -1$
$\underline{Z}$	complex quantity Z	$\underline{Z} = R + jX$
Geometry, vectors		
$\parallel$	parallel	$g_1 \parallel g_2$, R1 $\parallel$ R2
$\upuparrows$	parallel in the same dir.	$g \upuparrows h$
$\uparrow\downarrow$	parallel in opposite dir.	$g_1 \uparrow\downarrow g_2$
$\perp$	orthogonal, perpendicular	$g \perp h$
$\triangle$	triangle	$\triangle$ ABC
$\cong$	congruent,	$\triangle$ ABC $\cong$ $\triangle$ DEF
$\sim$	similar	$\triangle P_1P_2P_3 \sim \triangle ABC$
$\measuredangle$	angle	$\measuredangle ABC = \measuredangle (\overline{BA}, \overline{BC})$, $\measuredangle (\vec{a}, \vec{b})$
$\overline{AB}$	line segment AB	$\overline{P_1P_2}$
$\overset{\frown}{AB}$	arc AB	$\overset{\frown}{AB} = \measuredangle \gamma$
$\vec{A}, \vec{B}$	vector A, vector B	$\vec{C} = \vec{A} + \vec{B}$
$\lvert \vec{A} \rvert$	absolute value of vector A	$\lvert \vec{F} \rvert = 50$ N
Differentiation, integration		
Δ	difference	$\Delta U = U_2 - U_1$
y'	y prime	y' is the first derivation of y, first derivative
$\frac{dy}{dx}$	dy over dx	quotient $y' = dy/dx$
$\int$	integral	$\int f(x)\,dx$, $\int_a^b f(x)\,dx$
Exponents, logarithms		
a^x	*a to the power of x*	5^3, 10^x
exp	*exponential function*	$\exp x = e^x$, with e = 2.718…
log	*general logarithm*	
$\log_a$	*logarithm to the basis a*	$\log_3 9 = 2$
lg	*common logarithm*	lg 2 = 0.30103…
lb	*dyadic logarithm*	lb 8 = 3
ln	*natural logarithm*	ln 10 = 2.3025…
Trigonometry		
sin	sine	$\sin \alpha$
cos	cosine	$\sin^2 \alpha + \cos^2 \alpha = (\sin \alpha)^2 + (\cos \alpha)^2 = 1$
tan	tangent	$\tan \alpha = \sin \alpha / \cos \alpha$
cot	cotangent	$\cot \alpha = 1/\tan \alpha$
arcsin	arc cosine	$\sin \alpha = x \Rightarrow \arcsin x = \alpha$
arccos	arc cosine	$\cos \alpha = x \Rightarrow \arccos x = \alpha$
arctan	arc tangent	$\tan \alpha = x \Rightarrow \arctan x = \alpha$
arccot	arc cotangent	$\cot \alpha = x \Rightarrow \text{arccot}\, x = \alpha$

F

Exponents

Values less than 1 can be expressed by multiples of decimal powers with negative exponents.
Values greater than 1 can be expressed by multiples of decimal powers with positive exponents.

Value	0.001	0.01	0.1	1	10	100	1,000	10,000	100,000	1,000,000
Decimal powers	10^{-3}	10^{-2}	10^{-1}	10^{0}	10^{1}	10^{2}	10^{3}	10^{4}	10^{5}	10^{6}

Powers of two are used in digital engineering. The base here is 2.

Value	1/128	1/64	1/32	1/16	1/8	1/4	1/2	1	2	4	8	16	32	64	128
Powers of two	2^{-7}	2^{-6}	2^{-5}	2^{-4}	2^{-3}	2^{-2}	2^{-1}	2^{0}	2^{1}	2^{2}	2^{3}	2^{4}	2^{5}	2^{6}	2^{7}

Metric prefixes

Prefix symbol	Prefix	Meaning (factor)	Prefix symbol	Prefix	Meaning (factor)
y	yocto	10^{-24}	da	deca	10
z	zepto	10^{-21}	h	hecto	10^{2}
a	atto	10^{-18}	k	kilo	10^{3}
f	femto	10^{-15}	M	mega	10^{6}
p	pico	10^{-12}	G	giga	10^{9}
n	nano	10^{-9}	T	tera	10^{12}
µ	micro	10^{-6}	P	peta	10^{15}
m	milli	10^{-3}	E	exa	10^{18}
c	centi	10^{-2}	Z	zetta	10^{21}
d	deci	10^{-1}	Y	yotta	10^{24}

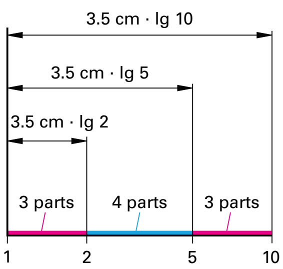
Binary prefixes

Prefix symbol	Prefix	Meaning (factor)
–	–	–
–	–	–
Ki	kibi	2^{10}
Mi	mebi	2^{20}
Gi	gibi	2^{30}
Ti	tebi	2^{40}
Pi	pebi	2^{50}
Ei	exbi	2^{60}
Zi	zebi	2^{70}
Yi	yobi	2^{80}

For large mass storage units, often the meaning of the physical quantities applies (decimal prefixes).

Prefixes may not be combined. You can assign only one prefix per unit.

Logarithms



Logarithmic division

The logarithm (log) indicates to which power a base has to be raised in order to obtain the logarithm argument. The following applies:

$a^b = c$, $\log_a c = b$

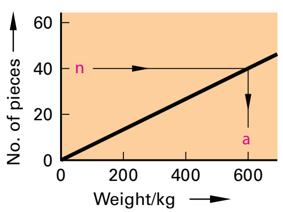
The common logarithm (lg) has the base 10. The natural logarithm (ln) has the base of the e-function (e=2.718...). The dyadic logarithm (lb) has the base 2.

Extensive number ranges can be represented in a more structured way when using a logarithmic scale.

$\log_a c = \frac{\ln c}{\ln a} = \frac{\lg c}{\lg a}$

1. $\log_a(cd) = \log_a c + \log_a d$
2. $\log_a \frac{c}{d} = \log_a c - \log_a d$
3. $\log_a(c^m) = m \cdot \log_a c$
4. $\lg_a \sqrt[n]{c} = \frac{1}{n} \log_a c$
5. $\lg x = \ln x / \ln 10$
6. $\ln x = \lg x / \lg e$
7. $\mathrm{lb}\, x = \lg x / \lg 2$

Calculation according to the rule of three



Calculation acc. to the rule of three of a proportional relation

Steps of approach	Example
Proportional relation (unit obtained by division)	
1. Statement	*n* elements have a weight of *a* kg
2. Calculation for 1 object	1 element has a weight of *a/n* kg
3. Calculation for *z* objects	*z* elements have a weight of *z* · *a/n* kg
Inverted proportional relation (unit obtained by multiplication)	
1. Statement	*n* workers need *a* hours
2. Calculation for 1 object	1 worker needs *n* · *a* hours
3. Calculation for *z* objects	*z* workers need *n* · *a/z* hours

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Transmission factors and logarithmic unit decibel

Term, definition	Formula, note	Comments, example
Transmission factor *T* **Gain factor *V*** **Attenuation factor *D***	Increase > 1 and decrease < 1: $T = V = S_2/S_1$ 1 $D = S_1/S_2$ 2	 S_1, S_2 quantities referring to transmission
Power-related measures Gain ratio *G* Attenuation ratio *A* To identify the value as a logarithmic quantity dB is added instead of a unit. This is because the value, actually, has no unit.	**Gain ratio** $G = 10\ \lg\ (P_2/P_1)$ 3 **Attenuation ratio** $A = 10\ \lg\ (P_1/P_2)$ 4 $G = -A$ 5 $A = -G$ 6 dB refers to decibel (a unit named after the American scientist Alexander Graham Bell)	**Example 1:** A filter circuit has an input of 500 mW and an output of 250 mW. What is a) the attenuation factor *D* and b) the attenuation ratio *A*? a) $D = S_1/S_2$ = 500 mW/250 mW = **2** b) A = 10 lg (500 mW/250 mW) = **3.01 dB**
Voltage-related measures, pressure-related measures Gain ratio *G* Attenuation ratio *A* Sound pressure transmission ratio T_p For these quantities, dB is also used instead of a unit.	**Gain ratio** $G = 20\ \lg\ (U_2/U_1)$ 7 $G = -A$ 8 **Attenuation ratio** $A = 20\ \lg\ (U_1/U_2)$ 9 $A = -G$ 10 Sound pressure transmission ratio $T_p = 20\ \lg\ (p_2/p_1)$ 11	**Example 2:** An amplifier has an input of 3 mV and an output of 5 V. What is a) the gain factor, b) the gain ratio? a) $V = U_2/U_1$ = 5 V/3 mV = **1,667** b) $G = 20\ \lg\ (U_2/U_1)$ = 20 lg (5 V/3 mV) = **64.4 dB**
Level in dB(*)	* placeholder for additional specifications	
Sound level, general	This quantity expresses the ratio between two values, one of which is an *agreed* reference value.	The reference value should be indicated in level specifications.
Power level L_P Identified by dB (1 mW) or dBm, Voltage level L_U Identified by dB (1 µV) or dBµ Sound pressure level L_p actually identified by dB (20 µN/m²)	**Power level** $L_P = 10\ \lg\ (P/1\ \text{mW})$ 12 **Voltage level** $L_U = 20\ \lg\ (U/1\ \mu\text{V})$ 13 **Sound pressure level** $L_p = 20\ \lg\ (p/20\ \mu\text{N/m}^2)$ 14	The agreed reference values are 1 mW for L_P, 1 mV for L_U and 20 µN/m² for L_p. **Example 3:** An aerial has an output of 80 mV. L_U = ? $L_U = 20\ \lg\ (U/1\ \mu\text{V})$ = **98 dBµ**
Rated sound pressure level Identified by dB(A), dB(B) or dB(C), depending on the correction	The measured quantity is the sound pressure level. The measuring values are modified with the help of filters A, B or C for frequencies other than 1,000 Hz.	The rated sound pressure level in dB(A) corresponds to a great extent to the human noise level sensation in phon.

A	attenuation ratio	L_U	voltage level	*U*	voltage
D	attenuation factor	lg	common logarithm	*V*	gain factor
G	gain ratio	*P*	power	Subscripts:	
L_P	power level	*p*	pressure	1 input, 2 output of the transmission path	
L_p	sound pressure level	*T*	transmission factor		

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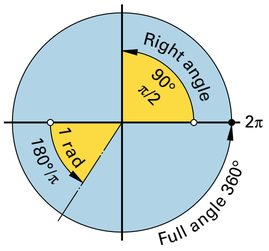
Figures	Explications	Notes, formulas

Angles



Angle dimensions

Units of measurement of angles are degrees, centesimal degrees, and radians.

The *round angle* has

a) 360° (degrees)
b) 400 gon (centesimal degrees)
c) 2π rad (radian)

The unit radian corresponds to the proportion of the circular arc length to the radius in a circle.

$$\alpha_r = \alpha° \cdot \frac{\pi}{180°} \quad (1)$$

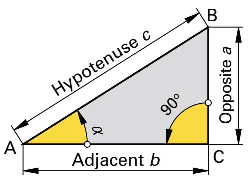
$$1 \text{ rad} = \frac{360°}{2\pi} = 57.296°$$

Important angles

Round angle	Straight angle	Right angle
360°	180°	90°
2π rad	π rad	$\frac{\pi}{2}$ rad
400 gon	200 gon	100 gon

Still customary in survey engineering: 1 gon = $(\pi/200)$ rad

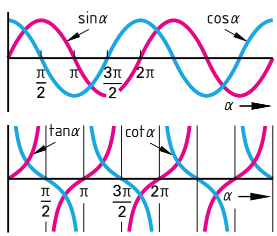
Trigonometric functions



Right-angled triangle

The longest side (c) of the right-angled triangle is referred to as the *hypotenuse*. It is the side opposite the right angle. The two other sides (a and b) of the triangle form the right angle. These sides are referred to as the *catheti*. The leg (a) opposite the acute angle α is the opposite. The leg contiguous to the angle α is the *adjacent* (b).

An angle in a right-angled triangle can be defined by its angle degrees or as a *ratio of two triangle sides*. The ratio of the sides depends on the size of the angle. That is why the ratios of two sides in a right-angled triangle are referred to as *angle functions* (function = dependence) or trigonometric functions.



Trigonometric functions

Sine $= \dfrac{\text{opposite}}{\text{hypotenuse}}$

Cosine $= \dfrac{\text{adjacent}}{\text{hypotenuse}}$

Tangent $= \dfrac{\text{opposite}}{\text{adjacent}}$

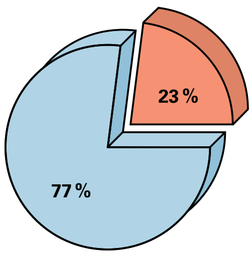
Cotangent $= \dfrac{\text{adjacent}}{\text{opposite}}$

$$\sin\alpha = \frac{a}{c} \quad (2) \qquad \cos\alpha = \frac{b}{c} \quad (3)$$

$$\tan\alpha = \frac{a}{b} \quad (4) \qquad \cot\alpha = \frac{b}{a} \quad (5)$$

α	0°	30°	45°	60°	90°
$\sin\alpha$	0	½	$\sqrt{2}/2$	$\sqrt{3}/2$	1
$\cos\alpha$	1	$\sqrt{3}/2$	$\sqrt{2}/2$	½	0
$\tan\alpha$	0	$\sqrt{3}/3$	1	$\sqrt{3}$	∞
$\cot\alpha$	∞	$\sqrt{3}$	1	$\sqrt{3}/3$	0

Percentage calculation



Per cent (pro cent in Latin) means "per hundred". The total quantity (basic quantity) is always equal to one hundred, the partial quantity (percentage) is expressed in per cent (= hundredths).

23% of 300 € equal to **69 €**
(23% = percentage; 300 € = basic value; 69 € = perc. amount)

$$\text{percentage} = \frac{100\% \cdot \text{perc. amount}}{\text{basic value}} \quad (8)$$

Percentage calculation

$$p = \frac{P \cdot 100\%}{B} \quad (6)$$

Calculation of interest

$$I = \frac{C_0 \cdot p \cdot n}{100\%} \quad (7)$$

Calculation of compound interest

$$C_n = C_0 \cdot \left(1 + \frac{p}{100\%}\right)^n \quad (9)$$

a, b, c	legs of a right-angled triangle	I	interest per year	α, β, γ	angles in a triangle
B	basic amount	n	term in years	$\alpha°$	degrees of an angle
C_0	starting capital	P	percentage amount	α_r	radian of an angle
C_n	capital after n years	p	percentage in %, interest rate in %		