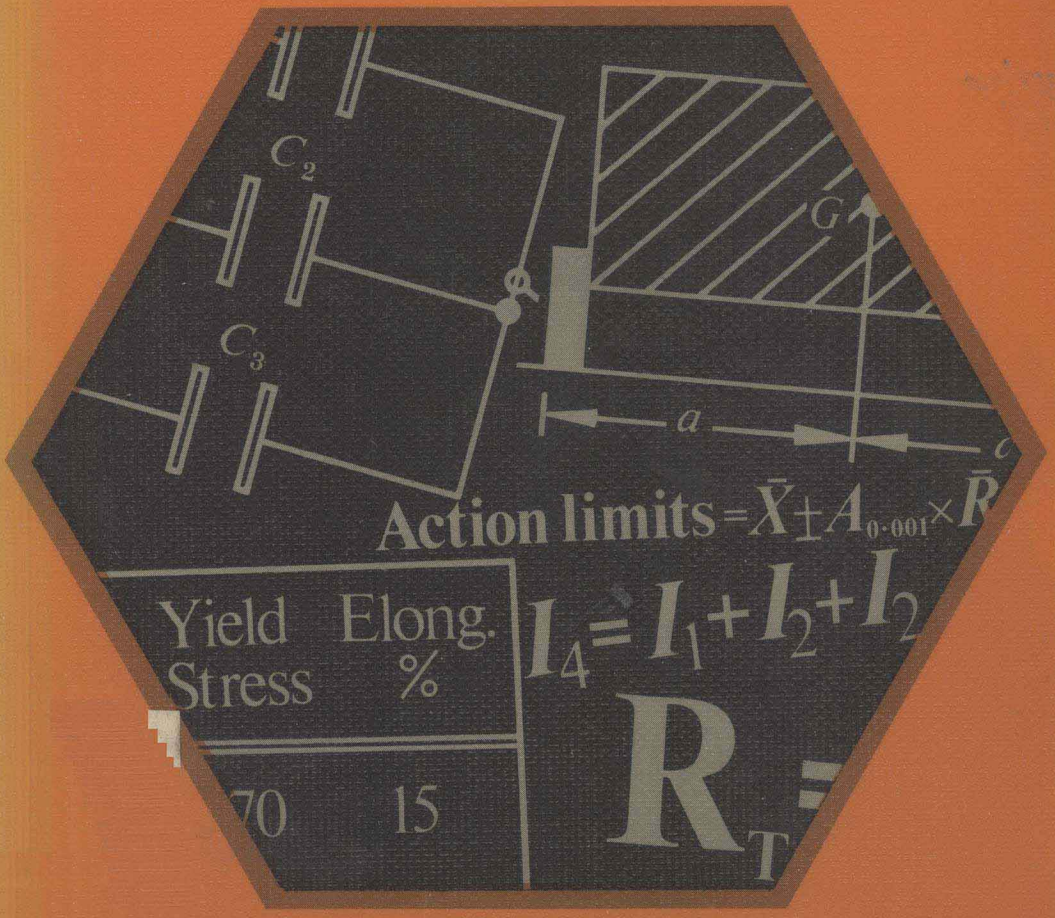
Tables, Data and Formulae for ENGINEERS

A. GREER and D. J. HANCOX



Tables, Data and Formulae for ENGINEERS

compiled by

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University of Queensland Press

Published by University of Queensland Press
St. Lucia, Queensland, 1977

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Typeset by Avontype, Bristol
Printed by The Pitman Press, Bath

British Standard Specification numbers referred to are those ruling at the time of publication.

References to British Standards are reproduced by kind permission of the British Standards Institution from whom can be obtained the full standard.

The EN numbers shown within the Properties of Materials section were those formerly used, and are for information only. They should not be used for specification purposes.

National Library of Australia
Cataloguing-in-Publication data

Tables, data and formulae for engineers.
Index.
Simultaneously published, London: Stanley Thornes.
ISBN 0 7022 1048 x.

1. Engineering mathematics – Formulae.
2. Engineering mathematics – Tables.
I. Greer, A., comp. II. Hancox, D.J., comp.

510.2462

Contents

Mathematical signs and abbreviations

Symbol	Term	Symbol	Term
$[\{( )\}]$	brackets	$\lim y$	limit of y
$+$	plus	$\to a$	approaches a
$-$	minus	∞	infinity
$\pm$	plus or minus	Σ	sum of
$\lvert a-b \rvert$	modulus of difference between a and b	Π	product of
		$\sqrt{x}$, $x^{\frac{1}{2}}$	square root of x
$\times$ or $\cdot$	multiplied by	$x^{\frac{1}{3}}$	cube root of x
$\div$ or $/$	divided by	e	base of natural logarithms
$=$	is equal to	$\log_a x$	logarithm to the base a
$\neq$	is not equal to	$\ln x$, $\log_e x$	natural logarithm of x
$\equiv$	is identical with	$\lg x$, $\log_{10} x$	common logarithm of x
$\hat{=}$	corresponds to	antilog	antilogarithm
$\approx$	is approximately equal to	$\exp x$, e^x	exponential function of x
$\sim$	is asymptotically equal to	$n!$	factorial n
$\propto$	varies directly as	$\binom{n}{p}$, ${}^nC_p$	binomial coefficient
$>$	is greater than	Δ, δ	increment or finite difference operator
$<$	is less than		
$\geqslant$	is equal to or greater than		
$\leqslant$	is equal to or less than	D	operator $\frac{\mathrm{d}}{\mathrm{d}x}$
$\gg$	is much greater than	$\int y\,\mathrm{d}x$	indefinite integral
$\ll$	is much less than	$\int_a^b y\,\mathrm{d}x$	integral between the limits of a and b
i, j	complex number $i = j = \sqrt{-1}$	$\oint y\,\mathrm{d}x$	around a closed contour
$\lvert z \rvert$	modulus of z	σ	standard deviation of a distributed variate
$\arg z$	argument of z		
x_i	ith value of the variate x	s	standard deviation for a sample
$\bar{x}$	average of several values of x	n	number in a sample
ρ	correlation coefficient	w	range
r	correlation coefficient for a sample	$\therefore$	therefore
p	probability	$\triangle$	triangle
$\angle$	angle	$\cup$	union
$\subset$	one subset	$\cap$	intersection
$\mathscr{E}$	universal set	A'	transpose of the matrix A
A^{-1}	inverse of the matrix A		
$\parallel$	parallel to		
$\perp$	perpendicular to		

Multiples and Submultiples

Multiplying factor	Prefix	Symbol	Multiplying factor	Prefix	Symbol
10^{12}	tera	T	10^{-6}	micro	μ
10^{9}	giga	G	10^{-9}	nano	n
10^{6}	mega	M	10^{-12}	pico	p
10^{3}	kilo	k	10^{-15}	femto	f
10^{-3}	milli	m	10^{-18}	atto	a

Greek letters

$A\ \alpha$ alpha	$E\ \epsilon$ epsilon	$I\ \iota$ iota	$N\ \nu$ nu	$P\ \rho$ rho	$\Phi\ \phi$ phi
$B\ \beta$ beta	$Z\ \zeta$ zeta	$K\ \kappa$ kappa	$\Xi\ \xi$ xi	$\Sigma\ \sigma$ sigma	$X\ \chi$ chi
$\Gamma\ \gamma$ gamma	$H\ \eta$ eta	$\Lambda\ \lambda$ lambda	$O\ o$ omicron	$T\ \tau$ tau	$\Psi\ \psi$ psi
$\Delta\ \delta$ delta	$\Theta\ \theta$ theta	$M\ \mu$ mu	$\Pi\ \pi$ pi	$Y\ \upsilon$ upsilon	$\Omega\ \omega$ omega

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Standard symbols and units for physical quantities

Quantity	Symbol	Unit	Quantity	Symbol	Unit
Acceleration–gravitational	g	m/s^2	Frequency	f	Hz
Acceleration–linear	a	m/s^2	Frequency, resonant	f_r	Hz
Admittance	Y	S			
Altitude above sea level	z	m	Gravitational acceleration	g	m/s^2
Amount of substance	n	mol	Gibbs function	G	J
Angle–plane	$\alpha, \beta, \theta, \phi$	rad	Gibbs function, specific	g	kJ/kg
Angle–solid	Ω, ω	steradian			
Angular acceleration	α	rad/s^2	Heat capacity, specific	c	kJ/kg K
Angular velocity	ω	rad/s	Heat flow rate	ϕ	W
Area	A	m^2	Heat flux intensity	ϕ	kW/m^2
Area–second moment of	I	m^4			
			Illumination	E	lx
Bulk modulus	K	N/m^2, Pa	Impedance	Z	Ω
			Inductance, self	L	H
Capacitance	C	μF	Inductance, mutual	M	H
Capacity	V	ℓ	Internal energy	U, E	J
Coefficient of friction	μ	no unit	Internal energy, specific	u, e	kJ/kg
Coefficient of linear expansion	α	/°C	Inertia, moment of	I, J	$kg\ m^2$
Conductance, electrical	G	S	Kinematic viscosity	ν	m^2/s, St
Conductance, thermal	h	kW/m^2K			
Conductivity, electrical	σ	kS/mm	Length	l	m
Conductivity, thermal	λ	W/m K	Light–velocity of	c	m/s
Cubical expansion–coefficient of	β	/°C	Light–wavelength of	λ	m
Current, electrical	I	A	Linear expansion–coefficient of	α	/°C
Current density	J	A/mm^2	Luminance	L	cd/m^2
			Luminous flux	ϕ	lm
Density	ρ	kg/m^3	Luminous intensity	I	cd
Density, relative	d	no unit			
Dryness fraction	x	no unit	Magnetic field strength	H	A/m
Dynamic viscosity	η	Ns/m^2, cP	Magnetic flux	Φ	Wb
			Magnetic flux density	B	T
Efficiency	η	no unit	Magnetomotive force	F	A
Elasticity, modulus of	E	N/m^2, Pa	Mass, macroscopic	m	kg
Electric field strength	E	V/m	Mass, microscopic	M	u
Electric flux	ϕ	C	Mass, rate of flow	V	m^3/s
Electric flux density	D	C/m^2	Mass, velocity	G	kg/m^2s
Energy	W	J	Modulus, bulk	K	N/m^2
Energy, internal	U, E	J	Modulus of elasticity	E	N/m^2
Energy, specific internal	u, e	kJ/kg	Modulus of rigidity	G	N/m^2
Enthalpy	H	J	Modulus of section	Z	m^3
Enthalpy, specific	h	kJ/kg	Molar mass of gas	M	kg/k mol
Entropy	S	kJ/K	Molar volume	V_m	m^3/k mol
Expansion–coefficient of cubical	β	/°C	Moment of force	M	Nm
			Moment of inertia	I, J	$kg\ m^2$
Expansion–coefficient of linear	α	/°C	Mutual inductance	M	H
			Number of turns in a winding	N	no unit
Field strength, electric	E	V/m			
Field strength, magnetic	H	A/m	Periodic time	T	s
Flux density, electric	D	C/m^2	Permeability, absolute	μ	μH/m
Flux density, magnetic	B	T	Permeability, absolute of free space	μ_0	μH/m
Flux, electric	ψ	C	Permeability, relative	μ_r	
Flux, magnetic	Φ	Wb	Permeance	Λ	H
Force	F	N	Permittivity, absolute	ϵ	pF/m
Force, resisting	R	N			

Quantity	Symbol	Unit	Quantity	Symbol	Unit
Permittivity of free space	ϵ_0	pF/m	Stress, direct	σ	N/m^2, Pa
Permittivity, relative	ϵ_r	no unit	Shear modulus of rigidity	G	N/m^2, Pa
Poisson's ratio	ν	no unit	Surface tension	γ	N/m
Polar moment of area	J	m^4	Susceptance	B	S
Power, apparent	S	VA			
Power, active	P	W	Temperature value	θ	°C
Power, reactive	Q	VA_r	Temperature coefficients of resistance	α, β, γ	/°C
Pressure	p	N/m^2, Pa			
Quantity of heat	Q	J	Thermodynamic temperature value	T	K
Quantity of electricity	Q	Ah, C	Time	t	s
Reactance	X	Ω	Torque	T	Nm
Reluctance	S	/H, A/Wb			
Relative density	d	no unit	Vapour velocity	C	m/s
Resistance, electrical	R	Ω	Velocity	v	m/s
Resisting force	R	N	Velocity, angular	ω	rad/s
Resistance, temperature coefficients of	α, β, γ	/°C	Velocity of light	c	Mm/s
			Velocity of sound	a	m/s
Resistivity, conductors	ρ	M Ω mm	Voltage	V	V
Resistivity, insulators	ρ	M Ω mm	Volume	V	m^3
Resonant frequency	f_r	Hz	Volume, rate of flow	V	m^3/s
			Viscosity, dynamic	η	Ns/m^2, cP
Second moment of area	I	m^4	Viscosity, kinematic	ν	m^2/s, cSt
Self inductance	L	H			
Shear strain	γ	no unit	Wavelength	λ	m
Shear stress	τ	N/m^2, Pa	Work	W	J
Specific gas constant	R	kJ/kg K			
Specific heat capacity	c	kJ/kg K	Young's modulus of elasticity	E	N/m^2, Pa
Specific volume	v	m^3/kg			
Strain, direct	ϵ	no unit			

Abbreviations for units

Unit	abb.	Unit	abb.	Unit	abb.	Unit	abb.
metre	m	steradian	sr	newton	N	mole	mol
angström	A	radian per second	rad/s	bar	bar	watt	W
square metre	m^2	hertz	Hz	millibar	mb	decibel	dB
cubic metre	m^3	revolution per minute	rev/min	standard atmosphere	atm	kelvin	K
litre	ℓ	kilogramme	kg	millimetre of mercury	mm Hg	centigrade	°C
second	s	gramme	g	poise	P	coulomb	C
minute	min.	tonne (= 1 Mg)	t	stokes	S, St	ampere	A
hour	h	seimen	S	joule	J	volt	V
lumen	lm	atomic mass unit	u	kilowatt hour	kW h	ohm	Ω
candela	cd	pascal	Pa	electron volt	eV	farad	F
lux	lx			calorie	cal	henry	H
day	d					weber	Wb
year	a					tesla	T
radian	rad						

Chemical symbols and atomic weights

Element	Symbol	Atomic number	Atomic weight
Actinium	Ac	89	(227)
Aluminium	Al	13	26.9815
Americium	Am	95	(243)
Antimony	Sb	51	124.7
Argon	A	18	39.948
Arsenic	As	33	74.9216
Astatine	At	85	~210
Barium	Ba	56	137.3
Berkelium	Bk	97	(247)
Beryllium	Be	4	9.01218
Bismuth	Bi	83	208.9806
Boron	B	5	10.81
Bromine	Br	35	79.904
Cadmium	Cd	48	112.40
Californium	Cf	98	(251)
Calcium	Ca	20	40.08
Carbon	C	6	12.011
Cerium	Ce	58	140.12
Cesium	Cs	55	132.9055
Chlorine	Cl	17	35.453
Chromium	Cr	24	51.996
Cobalt	Co	27	58.9332
Copper	Cu	29	63.546
Curium	Cm	96	(247)
Dysprobium	Dy	66	162.50
Erbium	Er	68	167.26
Europium	Eu	63	151.96
Fermium	Fm	100	(257)
Fluorine	F	9	18.9984
Gadolinium	Gd	64	157.2
Gallium	Ga	31	69.72
Germanium	Ge	32	72.59
Gold	Au	79	196.9665
Hafnium	Hf	72	178.49
Helium	He	2	4.00260
Holmium	Ho	67	164.9303
Hydrogen	H	1	1.0080
Indium	In	49	114.82
Iodine	I	53	126.9045
Iridium	Ir	77	193.2
Iron	Fe	26	55.84
Krypton	Kr	36	83.86
Lanthanum	La	57	138.905
Lawrencium	Lr	103	(257)
Lead	Pb	82	207.2
Lithium	Li	3	6.941
Lutetium	Lu	71	174.97
Magnesium	Mg	12	24.305
Manganese	Mn	25	54.9380
Mendelevium	Md	101	(256)
Mercury	Hg	80	200.5
Molybdenum	Mo	42	95.9
Neodymium	Nd	60	144.2
Neon	Ne	10	20.179
Neptunium	Np	93	237.0482
Nickel	Ni	28	58.7
Niobium	Nb	41	92.9064
Nitrogen	N	7	14.0067
Nobelium	No	102	(254)
Osmium	Os	76	190.2
Oxygen	O	8	15.999
Palladium	Pd	46	106.4
Phosphorus	P	15	30.9738
Platinum	Pt	78	195.0
Plutonium	Pu	94	(244)
Potassium	K	19	29.102
Praseodymium	Pr	59	140.907
Protoactinium	Pa	91	231.0359
Polonium	Po	84	(210)
Promethium	Pm	61	(145)
Radium	Ra	88	226.0254
Radon	Rn	86	(~222)
Rhenium	Re	75	186.2
Rhodium	Rh	45	102.9055
Rubidium	Rb	37	85.467
Ruthenium	Ru	44	101.0
Samarium	Sm	62	150.4
Scandium	Sc	21	44.9559
Selenium	Se	34	78.96
Silicon	Si	14	28.086
Silver	Ag	47	107.868
Sodium	Na	11	22.9898
Strontium	Sr	38	87.62
Sulphur	S	16	32.06
Tantalum	Ta	73	180.947
Technetium	Tc	43	98.9062
Tellurium	Te	52	127.60
Terbium	Tb	65	158.9254
Thallium	Tl	81	204.37
Thorium	Th	90	232.0381
Thulium	Tm	69	168.9342
Tin	Sn	50	118.6
Titanium	Ti	22	49.9
Tungsten	W	74	183.8
Uranium	U	92	238.029
Vanadium	V	23	50.941
Xenon	Xe	54	131.30
Ytterbium	Yb	70	173.0
Yttrium	Y	39	88.9059
Zinc	Zn	30	65.3
Zirconium	Zr	40	91.22

Specific heat of various substances

Substance	S.H. capacity kJ/kgK	Substance	S.H. capacity kJ/kgK	Substance	S.H. capacity kJ/kgK
Alcohol	2.604	Graphite	0.842	Quartz	0.787
Aluminium	0.896	Ice	2.110	Sand	0.816
Antimony	0.214	Iron, cast	0.544	Silica	0.800
Benzine	1.884	Iron, wrought	0.461	Silver	0.234
Brass	0.394	Kerosene	2.093	Soda	0.967
Brickwork	0.837	Lead	0.130	Steel, mild	0.486
Cadmium	0.239	Limestone	0.909	Steel, high carbon	0.490
Charcoal	0.837	Magnesia	0.930	Stone	0.837
Chalk	0.900	Marble	0.879	Sulphur	0.745
Coal	1.005	Masonry, brick	0.837	Sulphuric acid	1.382
Coke	0.850	Mercury	0.138	Tin	0.234
Copper	0.394	Naptha	1.298	Turpentine	1.976
Corundum	0.829	Nickel	0.456	Water	4.187
Ether	2.106	Oil, machine	1.675	Wood, fir	2.721
Fusel oil	2.361	Oil, olive	1.465	Wood, oak	2.387
Glass	0.812	Phosphorus	0.791	Wood, pine	1.955
Gold	0.130	Platinum	0.134	Zinc	0.398

Boiling points at atmospheric pressure

Substance	B.P. °C.	Substance	B.P. °C.	Substance	B.P. °C.
Alcohol	78	Ether	38	Brine	108
Alcohol wood	66	Linseed oil	264	Sulphuric acid	310
Ammonia	− 33	Mercury	358	Water, pure	100
Benzine	80	Napthalene	220	Water, sea	100.7
Bromine	63	Nitric acid	120		
Chloroform	60	Turpentine	157		

Loudness of sounds

Source	Intensity in decibels	Source	Intensity in decibels
Threshold of hearing	0	Loud conversation	70
Virtual silence	10	Door slamming	80
Quiet room	20	Riveting gun	90
Average home	30	Loud motor horn	100
Motor car	40	Thunder	110
Ordinary conversation	50	Aero-engine	120
Street traffic	60	Threshold of pain	130

Densities of various substances

Substance	Density g/cm³	Substance	Density g/cm³	Substance	Density g/cm³
Alcohol	0.79	Emery	4.0	Palm oil	0.97
Ammonia	0.89	Ether, sulphuric	0.72	Phosphorus	1.8
Asbestos	2.8	Fluoric acid	1.50	Petroleum oil	0.82
Benzine	0.69	Gasoline	0.70	Phosphoric acid	1.78
Borax	1.75	Glass	2.6	Quartz	2.6
Brick, common	1.8	Granite	2.65	Rape oil	0.92
Brick, fire	2.3	Gravel	1.75	Salt, common	2.1
Brick, hard	2.0	Gypsum	2.2	Sand, dry	1.6
Brick, pressed	2.15	Ice	0.9	Sand, wet	2.0
Brickwork in mortar	1.6	Ivory	1.85	Sandstone	2.3
Brickwork in cement	1.8	Kerosene	0.80	Slate	2.8
Cement	3.1	Limestone	2.6	Soapstone	2.7
Chalk	2.6	Linseed oil	0.92	Soil, black	2.0
Charcoal	0.4	Marble	2.7	Sulphur	2.0
Coal, anthracite	1.5	Masonry	2.4	Sulphuric acid	1.84
Coal, bituminious	1.27	Mica	2.8	Tar	1.00
Concrete	2.2	Mineral oil	0.92	Tile	1.8
Carbolic acid	0.96	Mortar	1.5	Turpentine	0.87
Carbon disulphide	1.26	Muriatic acid	1.2	Vinegar	1.08
Cotton seed oil	0.93	Naptha	0.76	Water	1.00
Earth, loose	1.2	Nitric acid	1.22	Water, sea	1.03
Earth, rammed	1.6	Olive oil	0.92	Whale oil	0.93

Latent heat of evaporation

Liquid	kJ/kg	Liquid	kJ/kg	Liquid	kJ/kg
Alcohol, ethyl	863	Bisulphide of carbon	372	Sulphur dioxide	381
Alcohol, methyl	1119	Ether	379	Turpentine	309
Ammonia	1230			Water	2248

Latent heat of fusion

Substance	kJ/kg	Substance	kJ/kg	Substance	kJ/kg
Aluminium	387	Paraffin	147.2	Sulphur	39.2
Bismuth	52.9	Phosphorus	21.1	Tin	59.7
Cast iron, grey	96.3	Lead	23.3	Zinc	117.8
Cast iron, white	138.2	Silver	88.2	Ice	334.9
Copper	180	Nickel	309	Magnesium	372

Abbreviations for words

Word	abb.	Word	abb.	Word	abb.	Word	abb.
absolute	abs.	crystalline	cryst.	infra-red	i.r.	relative humidity	r.h.
alternating current	a.c.	decomposition	decomp.	magneto-motive force	m.m.f.	root mean square	r.m.s.
anhydrous	anhyd.	dilute	dil.	maximum	max.	temperature	temp.
aqueous	aq.	direct current	d.c.	melting point	m.p.	standard temp. and pressure	s.t.p.
boiling point	b.p.	electromotive force	e.m.f.	minimum	min.	ultra violet	u.v.
calculated	calc.	equation	eqn.	potential difference	p.d.		
concentrated	conc.	equivalent	equiv.	recrystallised	recryst.		
constant	const.	experiment(al)	expt.				
corrected	corr.	freezing point	f.p.				
critical	crit.						

Commonly used constants

Constant	Numerical value	Logarithm	Constant	Numerical value	Logarithm
π	3.141593	0.4972	$1/\pi$	0.318310	$\bar{1}.5029$
2π	6.283185	0.7982	$\sqrt{\pi}$	1.772454	0.2486
$\pi/4$	0.785398	$\bar{1}.8951$	e	2.71828	0.4343
π^2	9.869604	0.9943	g	9.81	0.9917

Fixed points

Boiling point of liquid oxygen	−182.97°C
Melting point of ice (secondary point)	0.00°C
Triple point of water	0.01°C
Boiling point of water	100°C
Freezing point of zinc (secondary point)	419.505°C
Boiling point of liquid sulphur	444.60°C
Freezing point of liquid antimony	630.50°C
Melting point of silver	960.80°C
Melting point of gold	1063.00°C

Atmospheric pressure = 760 mm Hg = 1013 mb 1 bar = 10^2 kPa

Diameter of the earth = 12 750 km at the equator and 12 710 km at the poles.

Average radius of the earth = 6371 km

Speed of rotation of the earth = 1670 km/h

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Calculator check

Not all calculators have the same logic and the keys and stores do not always work in the same way. Therefore before starting to perform strings of calculations it pays to check that the calculator is working correctly. The following can be used to check the logic of the calculator.

$67.84+91.92+71.85 = 231.61$

$66.32-19.85 = 46.47$

$88.56-13.84+24.31 = 99.03$

$77.3\times64.8 = 5009.04$

$91.76\times3.84+817.52 = 1169.8784$

$(7.85+3.91)\times83.64 = 983.6064$

$91.3\times43.2\times68.0 = 268\,202.88$

$$\frac{91.76}{1.85} = 49.6$$

$$\frac{81.32\times14.63}{76.51} = 15.549\,752$$

$$\frac{84.3}{91.2}+\frac{76.51}{3.84} = 20.848\,821$$

for calculators without a memory this may be calculated thus

$$\left(\frac{84.3\times3.84}{91.2}+76.51\right)\div 3.84 = 20.848\,821$$

$$\frac{816.1}{94.3}-\frac{36.2}{14.7} = 6.191\,7098$$

for calculators without a memory this may be calculated thus

$$\left(\frac{-36.2\times94.3}{14.7}+816.1\right)\div 94.3 = 6.191\,7098$$

$$17.62-\frac{8.54}{3.61} = 15.254\,35$$

Factors

$$\begin{aligned}(a+b)^2 &= a^2+2ab+b^2\\ (a-b)^2 &= a^2-2ab+b^2\\ a^3+b^3 &= (a+b)(a^2-ab+b^2)\\ a^3-b^3 &= (a-b)(a^2+ab+b^2)\\ a^2-b^2 &= (a+b)(a-b)\\ (a+b)^3 &= a^3+3a^2b+3ab^2+b^3\\ (a-b)^3 &= a^3-3a^2b+3ab^2-b^3\end{aligned}$$

Indices

$$\begin{aligned}a^m\times a^n &= a^{m+n}\\ a^m\div a^n &= a^{m-n}\\ (a^m)^n &= a^{mn}\\ \sqrt[m]{a^n} &= a^{m/n}\\ \frac{1}{a^n} &= a^{-n}\\ a^0 &= 1\end{aligned}$$

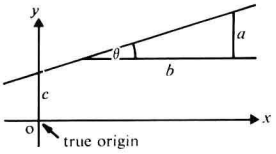
Logarithms

$$\begin{aligned}\text{If } N = a^x \text{ then } \log_a N &= x \text{ and } N = a^{\log_a N}\\ \log_a N &= \frac{\log_b N}{\log_b a}\\ \log(ab) &= \log a + \log b\\ \log\left(\frac{a}{b}\right) &= \log a-\log b\\ \log a^n &= n\log a\\ \log\sqrt[n]{a} &= \frac{1}{n}\log a\\ \log_a 1 &= 0\\ \log_e N &= 2.3026\log_{10} N\end{aligned}$$

Quadratic equation

$$\text{If } ax^2+bx+c = 0$$
$$x = \frac{-b\pm\sqrt{b^2-4ac}}{2a}$$

Graphs



$$m = \tan\theta = \frac{a}{b}$$

The equation of a straight line can be written in the form $y = mx+c$ where m is the gradient of the line and c is the intercept on the y-axis.
Non-linear relationships can sometimes be converted into linear relationships. The most common of these are given in the table below:

Equation	Plot	Gradient	Intercept
$y = ax^n+b$	$y \text{ v } x^n$	a	b
$y = \frac{a}{x^n}+b$	$y \text{ v } \frac{1}{x^n}$	a	b
$y = a\sqrt[n]{x}+b$	$y \text{ v } \sqrt[n]{x}$	a	b
$y = ax^n+bx^{n-1}$	$\frac{y}{x^{n-1}} \text{ v } x$	a	b
$y = ax^n$	$\log y \text{ v } \log x$	n	$\log a$
$y = ab^x$	$\log y \text{ v } x$	$\log b$	$\log a$
$y = ae^{bx}$	$\log y \text{ v } x$	$b \log e$	$\log a$

Variation

If $y \propto x$ then $y = kx$. This is direct variation.
If $y \propto \frac{1}{x}$ then $y = \frac{k}{x}$. This is inverse variation.

If p varies directly as t and inversely as v then $p = \frac{kt}{v}$.
This is joint variation.

Binomial theorem

$$(a+b)^n = a^n+na^{n-1}b+\frac{n(n-1)\,a^{n-2}\,b^2}{2!}+\ldots b^n$$

$$(1+x)^n = 1+nx+\frac{n(n-1)x^2}{2!}+\ldots x^n$$

If n is a positive integer the series is finite and is true for all values of x.
If n is negative or fractional the series is infinite and is valid only if x lies between -1 and $+1$.

Series

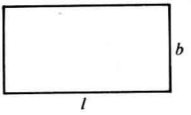
$$e = 1+1+\frac{1}{2!}+\frac{1}{3!}+\ldots$$

$$e^x = 1+x+\frac{x^2}{2!}+\frac{x^3}{3!}+\ldots$$

$$e^{-x} = 1-x+\frac{x^2}{2!}-\frac{x^3}{3!}+\ldots$$

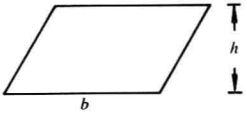
Areas of plane figures

Rectangle



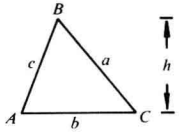
Area $= lb$
Perimeter $= 2l+2b$

Parallelogram



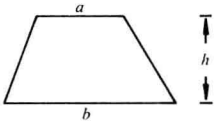
Area $= bh$

Triangle



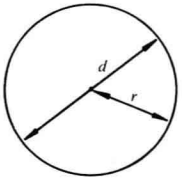
Area $= \frac{1}{2}bh = \sqrt{s(s-a)(s-b)(s-c)}$
$= \frac{1}{2}ab \sin C$
Where $s = \frac{a+b+c}{2}$

Trapezium



Area $= \frac{1}{2}h(a+b)$

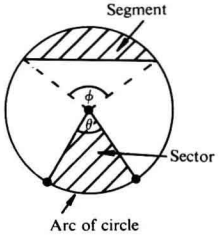
Circle



Area $= \pi r^2 = \frac{\pi d^2}{4}$
Circumference $= \pi d = 2\pi r$

Segment of a circle

Sector of a circle



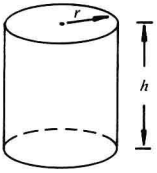
Area $= \frac{1}{2}r^2(\phi - \sin\phi)$
(ϕ in radians)

Area $= \pi r^2 \times \frac{\theta}{360}$

Length of arc $= 2\pi r \times \frac{\theta}{360}$
(θ in degrees)

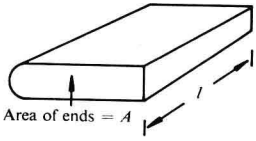
Volumes and surface areas

Cylinder



Volume $= \pi r^2 h$
Curved surface area $= 2\pi rh$
Total surface area $= 2\pi rh + 2\pi r^2$
$= 2\pi r(r+h)$

Any solid having a uniform cross-section

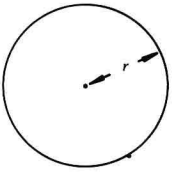


Volume $= Al$
Curved surface area
= perimeter of cross-section $\times$ length
Total surface area
= curved surface area + area of ends

Cone

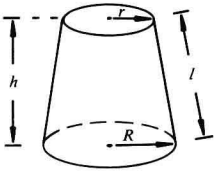
Volume $= \frac{1}{3}\pi r^2 h$ (h = vertical height)
Curved surface area $= \pi rl$ (l = slant height)
Total surface area $= \pi rl + \pi r^2$

Sphere



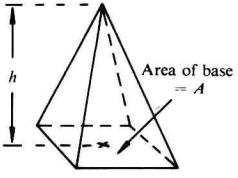
Volume $= \frac{4}{3}\pi r^3$
Surface area $= 4\pi r^2$

Frustrum of a cone



Volume $= \frac{1}{3}\pi h(R^2 + Rr + r^2)$
Curved surface area $= \pi(R+r)l$
Total surface area $= \pi(R+r)l + \pi R^2 + \pi r^2$

Pyramid



Volume $= \frac{1}{3}Ah$

Prism

Any solid with two faces parallel and having a constant cross-section. The end faces must be triangles, quadrilaterals or polygons.

Volume = area of cross-section $\times$ length of prism

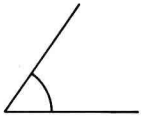
Angles

$$1 \text{ revolution} = 360° = 2\pi \text{ radians}$$
$$60' = 1°$$
$$60'' = 1'$$
$$1° = \frac{2\pi}{360} \text{ radians}$$
$$1 \text{ radian} = \frac{360}{2\pi} = 57.3°$$

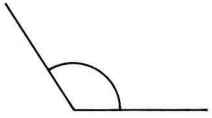
$45° = \frac{\pi}{4}$ radians $\quad 90° = \frac{\pi}{2}$ radians

$60° = \frac{\pi}{3}$ radians $\quad 180° = \pi$ radians

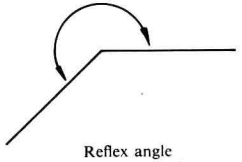
$120° = \frac{2\pi}{3}$ radians $\quad 270° = \frac{3\pi}{2}$ radians



Acute angle
(less than 90°)



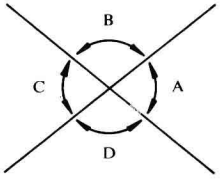
Obtuse angle
(between 90° and 180°)



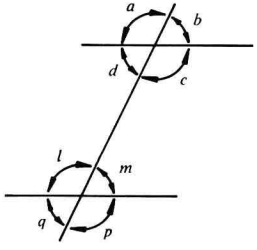
Reflex angle
(greater than 180°)

Complementary angles are angles whose sum is 90°

Supplementary angles are angles whose sum is 180°



The vertically opposite angles are equal
$\angle A = \angle C$ and $\angle B = \angle D$



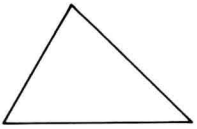
When two parallel lines are cut by a transversal

(i) The corresponding angles are equal:
$a = l$; $b = m$; $c = p$; $b = q$

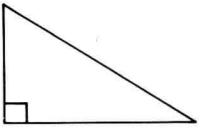
(ii) The alternate angles are equal: $d = m$; $c = l$

(iii) The interior angles are supplementary:
$d + l = 180°$; $c + m = 180°$

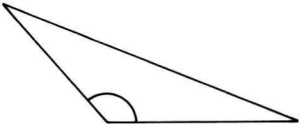
Triangles



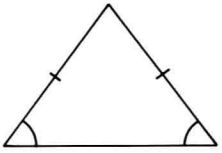
Acute-angled (all angles less than 90°)



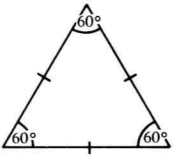
Right-angled (one angle = 90°)



Obtuse angled (one angle greater than 90°)



Isosceles triangle (two sides and two angles equal)

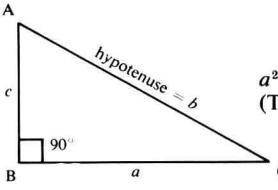


Equilateral triangle (all sides and all angles equal)

The sum of the angles of a triangle equals 180°

Pythagoras' theorem

In a right-angled triangle the square on the hypotenuse is equal to the sum of the squares on the other two sides.



$a^2+c^2 = b^2$

(The hypotenuse lies opposite to the right-angle)

Congruency

Two triangles are congruent if they are equal in every respect. Any of the following are sufficient to prove that two triangles are congruent:

(i) One side and two angles in one triangle equal to one side and two similarly located angles in the second triangle.

(ii) Two sides and the angle between them in one triangle equal to two sides and the angle between them in the second triangle.

(iii) Three sides of one triangle equal to three sides in the second triangle.

(iv) In right-angled triangles the hypotenuses are equal and one other side in each triangle also equal.

Similar triangles

Two triangles are similar if they are equi-angular. If in $\triangle$s ABC and XYZ, $\angle A = \angle X$, $\angle B = \angle Y$ and $\angle C = \angle Z$ then

$$\frac{AB}{XY} = \frac{AC}{XZ} = \frac{BC}{YZ}$$

Any of the following is sufficient to prove that two triangles are similar:

(i) Two angles in one triangle equal to two angles in the second triangle.

(ii) Two sides in one triangle are proportional to two sides in the second triangle and the angle between these sides in each triangle is equal.

(iii) Three sides in one triangle are proportional to the three sides in the second triangle.

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