CONSTANTS, CONVERSIONS, and CHARACTERS

DECIMAL MULTIPLIER PREFIXES

Prefix	Symbol	Multiplier
exa	E	10^{18}
peta	P	10^{15}
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
hecto	h	10^{2}
deka	da	10^{1}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}
atto	a	10^{-18}

EQUIVALENCY SYMBOLS

Symbol	Meaning
$\propto$	Proportional
~	Roughly equivalent
≈	Approximately
≅	Nearly equal
=	Equal
≡	Identical to, defined as
≠	Not equal
>>	Much greater than
>	Greater than
≥	Greater than or equal to
<<	Much less than
<	Less than
≤	Less than or equal to
∴	Therefore
°	Degrees
′	Minutes or feet
"	Seconds or inches

UNITS OF LENGTH

1 inch (in)	=	2.54 centimeters (cm)
1 foot (ft)	=	30.48 cm = 0.3048 m
1 yard (yd)	≅	0.9144 meter
1 meter (m)	≅	39.37 inches
1 kilometer (km)	≅	0.54 nautical mile
	≅	0.62 statute mile
	≅	1093.6 yards
	≅	3280.8 feet
1 statute mile	≅	0.87 nautical mile
(sm or stat. mile)	≅	1.61 kilometers
	=	1760 yards
	=	5280 feet
1 nautical mile	≅	1.15 statute miles
(nm or naut. mile)	≅	1.852 kilometers
	≅	2025 yards
	≅	6076 feet
1 furlong	=	1/8 mi (220 yds)

UNITS OF SPEED

1 foot/sec (fps)	≅	0.59 knot (kt)*
	≅	0.68 stat. mph
	≅	1.1 kilometers/hr
1000 fps	≈	600 knots
1 kilometer/hr	≅	0.54 knot
(km/hr)	≅	0.62 stat. mph
	≅	0.91 ft/sec
1 mile/hr (stat.)	≅	0.87 knot
(mph)	≅	1.61 kilometers/hr
	≅	1.47 ft/sec
1 knot*	≅	1.15 stat. mph
	≅	1.69 feet/sec
	≅	1.85 kilometer/hr
	≅	0.515 m/sec

*A knot is 1 nautical mile per hour.

UNITS OF VOLUME

1 gallon	≅	3.78 liters
	≅	231 cubic inches
	≅	0.1335 cubic ft
	≅	4 quarts
	≅	8 pints
1 fl ounce	≅	29.57 cubic centimeter (cc) or milliliters (ml)
1 in^3	≅	16.387 cc

UNITS OF AREA

1 sq meter	≅	10.76 sq ft
1 sq in	≅	645 sq millimeters (mm)
	=	1,000,000 sq mil
1 mil	=	0.001 inch
1 acre	=	43,560 sq ft

UNITS OF WEIGHT

1 kilogram (kg)	≅	2.2 pounds (lbs)
1 pound	≅	0.45 Kg
	=	16 ounce (oz)
1 oz	=	437.5 grains
1 carat	≅	200 mg
1 stone (U.K.)	≅	6.36 kg

NOTE: These are the U.S. customary (avoirdupois) equivalents, the troy or apothecary system of equivalents, which differ markedly, was used long ago by pharmacists.

UNITS OF POWER / ENERGY

1 H.P.	=	33,000 ft-lbs/min
	=	550 ft-lbs/sec
	≅	746 Watts
	≅	2,545 BTU/hr

(BTU = British Thermal Unit)

1 BTU	≅	1055 Joules
	≅	778 ft-lbs
	≅	0.293 Watt-hrs

SCALES

OCTAVES

"N" Octaves = Freq to Freq x 2^N
i.e. One octave would be 2 to 4 GHz
Two Octaves would be 2 to 8 GHz
Three octaves would be 2 to 16 GHz

DECADES

"N" Decades = Freq to Freq x 10^N
i.e. One decade would be 1 to 10 MHz
Two decades would be 1 to 100 MHz
Three decades would be 1 to 1000 MHz

TEMPERATURE CONVERSIONS

$^\circ F = (9/5)^\circ C + 32$

$^\circ C = (5/9)(^\circ F - 32)$

$^\circ K = ^\circ C + 273.16$

$^\circ F = (9/5)(^\circ K - 273) + 32$

$^\circ C = ^\circ K - 273.16$

$^\circ K = (5/9)(^\circ F - 32) + 273$

UNITS OF TIME

1 year	=	365.2 days
1 fortnight	=	14 nights (2 weeks)
1 century	=	100 years
1 millennium	=	1,000 years

NUMBERS

1 decade	=	10
1 Score	=	20
1 Billion	=	1 x 10^9 (U.S.) (thousand million)
	=	1 x 10^{12} (U.K.)

RULE OF THUMB FOR ESTIMATING DISTANCE TO LIGHTNING / EXPLOSION:

km - Divide 3 into the number of seconds which have elapsed between seeing the flash and hearing the noise.
miles - Multiply 0.2 times the number of seconds which have elapsed between seeing the flash and hearing the noise.

Note: Sound vibrations cause a change of density and pressure within a media, while electromagnetic waves do not. An audio tone won't travel through a vacuum but can travel at 1100 ft/sec through air. When picked up by a microphone and used to modulate an EM signal, the modulation will travel at the speed of light.

Physical Constant	Quoted Value	S*	SI unit	Symbol
Avogadro constant	6.0221367×10^{23}	36	mol^{-1}	N_A
Bohr magneton	$9.2740154 \times 10^{-24}$	31	$J \cdot T^{-1}$	μ_B
Boltzmann constant	1.380658×10^{-23}	12	$J \cdot K^{-1}$	$k(=R\ N_A)$
Electron charge	$1.602177\ 33 \times 10^{-19}$	49	C	-e
Electron specific charge	$-1.758819\ 62 \times 10^{11}$	53	$C \cdot kg^{-1}$	$-e/m_e$
Electron rest mass	$9.1093897 \times 10^{-31}$	54	kg	m_e
Faraday constant	9.6485309×10^{4}	29	$C \cdot mol^{-1}$	F
Gravity (Standard Acceleration)	9.80665 or 32.174	0	m/sec^2 ft/sec^2	g
Josephson frequency to voltage ratio	4.8359767×10^{14}	0	$Hz \cdot V^{-1}$	2e/hg
Magnetic flux quantum	$2.06783461 \times 10^{-15}$	61	Wb	ϕ_o
Molar gas constant	8.314510	70	$J \cdot mol^{-1} \cdot K^{-1}$	R
Natural logarithm base	$\cong$ 2.71828	-	dimensionless	*e*
Newtonian gravitational constant	6.67259×10^{-11}	85	$m^3 \cdot kg^{-1} \cdot s^{-2}$	G or K
Permeability of vacuum	$4\pi \times 10^{-7}$	d	H/m	μ_o
Permittivity of vacuum	$\cong 8.8541878 \times 10^{-12}$	d	F/m	ϵ_o
Pi	$\cong$ 3.141592654		dimensionless	π
Planck constant Planck constant/2π	6.62659×10^{-34} $1.05457266 \times 10^{-34}$	40 63	$J \cdot s$ $J \cdot s$	h $h(=h2\pi)$
Quantum of circulation	$3.63694807 \times 10^{-4}$	33	$J \cdot s \cdot kg^{1}$	$h/2m_e$
Radius of earth (Equatorial)	6.378×10^{6} or 3963		m miles	
Rydberg constant	$1.0973731534 \times 10^{7}$	13	m^{-1}	R_χ
Speed of light	2.9979246×10^{8}	1	$m \cdot s^{-1}$	c
Speed of sound (dry air @ std press & temp)	331.4	-	$m \cdot s^{-1}$	-
Standard volume of ideal gas	22.41410×10^{-3}	19	$m^3 \cdot mol^{-1}$	V_m
Stefan-Boltzmann constant	5.67051×10^{-8}	19	$W \cdot K^{-4} \cdot m^{-2}$	σ

* S is the one-standard-deviation uncertainty in the last units of the value, d is a defined value.
(A standard deviation is the square root of the mean of the sum of the squares of the possible deviations)

THE SPEED OF LIGHT			
ACTUAL	UNITS	RULE OF THUMB	UNITS
$\cong 2.9979246 \times 10^8$	m/sec	$\approx 3 \times 10^8$	m/sec
$\cong 299.79$	m/µsec	≈ 300	m/µsec
$\cong 3.27857 \times 10^8$	yd/sec	$\approx 3.28 \times 10^8$	yd/sec
$\cong 5.8275 \times 10^8$	NM/hr	$\approx 5.8 \times 10^8$	NM/hr
$\cong 1.61875 \times 10^5$	NM/sec	$\approx 1.62 \times 10^5$	NM/sec
$\cong 9.8357105 \times 10^8$	ft/sec	$\approx 1 \times 10^9$	ft/sec

SPEED OF LIGHT IN VARIOUS MEDIUMS

The speed of EM radiation through a substance such as cables is defined by the following formula:

$$V = c/(\mu_r \epsilon_r)^{1/2}$$

Where: μ_r = relative permeability
ϵ_r = relative permittivity

The real component of ϵ_r = dielectric constant of medium.

EM propagation speed in a typical cable might be 65-90% of the speed of light in a vacuum.

APPROXIMATE SPEED OF SOUND (MACH 1)

Sea Level (CAS/TAS)		**36,000 ft*** (TAS)	(CAS)
1230 km/hr	Decreases	1062 km/hr	630 km/hr
765 mph	Linearly	660 mph	391 mph
665 kts	To ⇒	573 kts	340 kts

* The speed remains constant until 82,000 ft, when it increases linearly to 1215 km/hr (755 mph, 656 kts) at 154,000 ft. Also see section 8-2 for discussion of Calibrated Air Speed (CAS) and True Airspeed (TAS) and a plot of the speed of sound vs altitude.

SPEED OF SOUND IN VARIOUS MEDIUMS

Substance	Speed (ft/sec)
Vacuum	Zero
Air	1,100
Fresh Water	4,700
Salt Water	4,900
Glass	14,800

DECIMAL / BINARY / HEX CONVERSION TABLE

Decimal	Binary	Hex	Decimal	Binary	Hex	Decimal	Binary	Hex
1	00001	01h	11	01011	0Bh	21	10101	15h
2	00010	02h	12	01100	0Ch	22	10110	16h
3	00011	03h	13	01101	0Dh	23	10111	17h
4	00100	04h	14	01110	0Eh	24	11000	18h
5	00101	05h	15	01111	0Fh	25	11001	19h
6	00110	06h	16	10000	10h	26	11010	1Ah
7	00111	07h	17	10001	11h	27	11011	1Bh
8	01000	08h	18	10010	12h	28	11100	1Ch
9	01001	09h	19	10011	13h	29	11101	1Dh
10	01010	0Ah	20	10100	14h	30	11110	1Eh

When using hex numbers it is always a good idea to use "h" as a suffix to avoid confusion with decimal numbers.

To convert a decimal number above 16 to hex, divide the number by 16, then record the integer resultant and the remainder. Convert the remainder to hex and write this down - this will become the far right digit of the final hex number. Divide the integer you obtained by 16, and again record the new integer result and new remainder. Convert the remainder to hex and write it just to the left of the first decoded number. Keep repeating this process until dividing results in only a remainder. This will become the left-most character in the hex number. i.e. to convert 60 (decimal) to hex we have 60/16 = 3 with 12 remainder. 12 is C (hex) - this becomes the right most character. Then 3/16=0 with 3 remainder. 3 is 3 (hex). This becomes the next (and final) character to the left in the hex number, so the answer is 3C.

GREEK ALPHABET

Case		Greek Alphabet Name	English Equivalent
Upper	Lower		
Α	α	alpha	a
Β	β	beta	b
Γ	γ	gamma	g
Δ	δ	delta	d
Ε	ϵ	epsilon	ĕ
Ζ	ζ	zeta	z
Η	η	eta	ē
Θ	θ , ϑ	theta	th
Ι	ι	iota	i
Κ	κ	kappa	k
Λ	λ	lambda	l
Μ	μ	mu	m

Case		Greek Alphabet Name	English Equivalent
Upper	Lower		
Ν	ν	nu	n
Ξ	ξ	xi	x
Ο	ο	omicron	ŏ
Π	π	pi	p
Ρ	ρ	rho	r
Σ	σ	sigma	s
Τ	τ	tau	t
ϒ	υ	upsilon	u
Φ	ϕ, φ	phi	ph
Χ	χ	chi	ch
Ψ	ψ	psi	ps
Ω	ω	omega	ō

LETTERS FROM THE GREEK ALPHABET COMMONLY USED AS SYMBOLS

Symbol	Name	Use
α	alpha	space loss, angular acceleration, or absorptance
β	beta	3 dB bandwidth or angular field of view [radians]
Γ	Gamma	reflection coefficient
γ	gamma	electric conductivity, surface tension, missile velocity vector angle, or gamma ray
Δ	Delta	small change or difference
δ	delta	delay, control forces and moments applied to missile, or phase angle
ϵ	epsilon	emissivity [dielectric constant] or permittivity [farads/meter]
η	eta	efficiency or antenna aperture efficiency
Θ	Theta	angle of lead or lag between current and voltage
θ or ϑ	theta	azimuth angle, bank angle, or angular displacement
Λ	Lambda	acoustic wavelength or rate of energy loss from a thermocouple
λ	lambda	wavelength or Poisson Load Factor
μ	mu	micro 10^{-6} [micron], permeability [henrys/meter], or extinction coefficient [optical region]
ν	nu	frequency
π	pi	3.141592654+
ρ	rho	charge/mass density, resistivity [ohm-meter], VSWR, or reflectance
Σ	Sigma	algebraic sum
σ	sigma	radar cross section [RCS], Conductivity [1/ohm-meter], or Stefan-Boltzmann constant
Τ	Tau	VSWR reflection coefficient
τ	tau	pulse width, atmospheric transmission, or torque
Φ	Phi	magnetic/electrical flux, radiant power [optical region], or Wavelet's smooth function [low pass filter]
ϕ or φ	phi	phase angle, angle of bank, or beam divergence [optical region]
Ψ	Psi	time-dependent wave function or Wavelet's detail function [high pass filter]
ψ	psi	time-independent wave function, phase change, or flux linkage [weber]
Ω	Omega	Ohms [resistance] or solid angle [optical region]. Note: inverted symbol is conductance [mhos]
ω	omega	carrier frequency in radians per second

MORSE CODE and PHONETIC ALPHABET

A - alpha	• -	J - juliett	• - - -	S - sierra	• • •	1	• - - - -
B - bravo	- • • •	K - kilo	- • -	T - tango	-	2	• • - - -
C - charlie	- • - •	L - lima	• - • •	U - uniform	• • -	3	• • • - -
D - delta	- • •	M - mike	- -	V - victor	• • • -	4	• • • • -
E - echo	•	N - november	- •	W - whiskey	• - -	5	• • • • •
F - foxtrot	• • - •	O - oscar	- - -	X - x-ray	- • • -	6	- • • • •
G - golf	- - •	P - papa	• - - •	Y - yankee	- • - -	7	- - • • •
H - hotel	• • • •	Q - quebec	- - • -	Z - zulu	- - • •	8	- - - • •
I - india	• •	R - romeo	• - •	0	- - - - -	9	- - - - •

Note: The International Maritime Organization agreed to officially stop Morse code use by February 1999, however use may continue by ground based amateur radio operators (The U.S. Coast Guard discontinued its use in 1995).

Basic Math / Geometry Review

EXPONENTS

$$a^x a^y = a^{x+y}$$

$$a^x / a^y = a^{x-y}$$

$$(a^x)^y = a^{xy}$$

$$a^0 = 1$$

Example:

$$\frac{x}{\sqrt{x}} = x \cdot x^{-\frac{1}{2}} = x^{(1-\frac{1}{2})} = x^{\frac{1}{2}} = \sqrt{x}$$

LOGARITHMS

$$\log(xy) = \log x + \log y$$

$$\log(x/y) = \log x - \log y$$

$$\log(x^N) = N \log x$$

If $z = \log x$ then $x = 10^z$

Examples: $\log 1 = 0$

$\log 1.26 = 0.1$; $\log 10 = 1$

if $10 \log N = dB\#$,

then $10^{(dB\#/10)} = N$

TRIGONOMETRIC FUNCTIONS

$$\sin x = \cos(x - 90°)$$

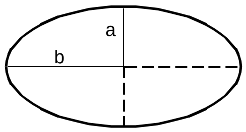
$$\cos x = -\sin(x - 90°)$$

$$\tan x = \sin x / \cos x = 1 / \cot x$$

$$\sin^2 x + \cos^2 x = 1$$

A radian is the angular measurement of an arc which has an arc length equal to the radius of the given circle, therefore there are 2π radians in a circle. One radian = $360°/2\pi = 57.296....°$

ELLIPSE

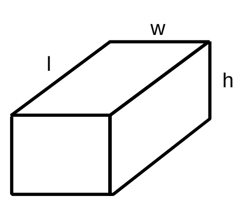


Area $= \pi a b$

Approx circumference

$$= 2\pi \sqrt{\frac{a^2 + b^2}{2}}$$

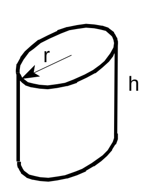
RECTANGLULAR SOLID



Area $= lw$

Volume $= lwh$

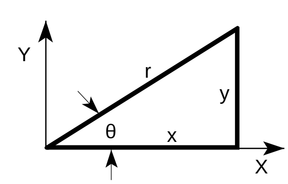
CYLINDER



Volume $= \pi r^2 h$

Lateral surface area $= 2\pi rh$

ANGLES



$\sin\theta = y/r$ $\cos\theta = x/r$

$\tan\theta = y/x$ $r^2 = x^2 + y^2$

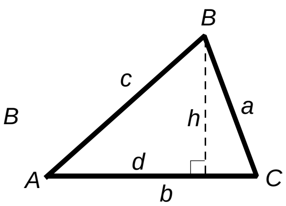
TRIANGLES

Angles: $A + B + C = 180°$

$c^2 = a^2 + b^2 - 2ab \cos C$

Area $= 1/2\, bh = 1/2\, ac \sin B$

$c = \sqrt{d^2 + h^2}$



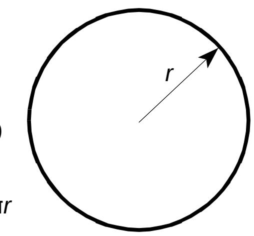
SPHERE

Surface area $= 4\pi r^2$

Volume $= 4/3\, \pi r^3$

Cross Section (circle)
Area $= \pi r^2$

Circumference (c) $= 2\pi r$



DERIVATIVES

Assume: a = fixed real #; u, v & w are functions of x

d(a)/dx = 0 ; d(sin u)/dx = du(cos u)/dx

d(x)/dx = 1 ; d(cos v)/dx = -dv(sin v)/dx

d(uvw)/dx = uvdw/dx + vwdu/dx + uwdv/dx +...etc

INTEGRALS

Note: All integrals should have a constant of integration added

Assume: a = fixed real #; u, & v are functions of x

$\int adx = ax$ and $\int a\, f(x)dx = a\int f(x)dx$

$\int (u+v)dx = \int udx + \int vdx$; $\int e^x dx = e^x$

$\int(\sin ax)dx = -(\cos ax)/a$; $\int(\cos ax)dx = (\sin ax)/a$