the industry standard

power engineering
TRAINING SYSTEMS

Handbook of Formulae and Physical Constants

For The Use Of Students And Examination Candidates

Approved by the Interprovincial Power Engineering Curriculum Committee and the Provincial Chief Inspectors' Association's Committee for the standardization of Power Engineer's Examinations n Canada.

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Names in the Metric System

VALUE	EXPONENT	SYMBOL	PREFIX
1 000 000 000 000	10^{12}	T	tera
1 000 000 000	10^{9}	G	giga
1 000 000	10^{6}	M	mega
1 000	10^{3}	k	kilo
100	10^{2}	h	hecto
10	10^{1}	da	deca
0.1	10^{-1}	d	deci
0.01	10^{-2}	c	centi
0.001	10^{-3}	m	milli
0.000 001	10^{-6}	μ	micro
0.000 000 001	10^{-9}	n	nano
0.000 000 000 001	10^{-12}	p	pico

Conversion Chart for Metric Units

To Convert	To Milli-	To Centi-	To Deci-	To Metre, Gram, Litre	To Deca-	To Hecto-	To Kilo-
Kilo-	x 10^{6}	x 10^{5}	x 10^{4}	x 10^{3}	x 10^{2}	x 10^{1}	
Hecto-	x 10^{5}	x 10^{4}	x 10^{3}	x 10^{2}	x 10^{1}		x 10^{-1}
Deca-	x 10^{4}	x 10^{3}	x 10^{2}	x 10^{1}		x 10^{-1}	x 10^{-2}
Metre, Gram, Litre	x 10^{3}	x 10^{2}	x 10^{1}		x 10^{-1}	x 10^{-2}	x 10^{-3}
Deci-	x 10^{2}	x 10^{1}		x 10^{-1}	x 10^{-2}	x 10^{-3}	x 10^{-4}
Centi-	x 10^{1}		x 10^{-1}	x 10^{-2}	x 10^{-3}	x 10^{-4}	x 10^{-5}
Milli-		x 10^{-1}	x 10^{-2}	x 10^{-3}	x 10^{-4}	x 10^{-5}	x 10^{-6}

BASIC UNITS

SI	IMPERIAL

DISTANCE

1 metre (1 m) = 10 decimetres (10 dm)
= 100 centimetres (100 cm)
= 1000 millimetres (1000 mm)

1 decametre (1 dam) = 10 m
1 hectometre (1 hm) = 100 m
1 kilometre (1 km) = 1000 m

12 in. = 1 ft
3 ft = 1 yd
5280 ft = 1 mile
1760 yd = 1 mile

Conversions:

1 in. = 25.4 mm
1 ft = 30.48 cm
1 mile = 1.61 km
1 yd = 0.914 m
1 m = 3.28 ft

Area

1 sq metre (1 m^2) = 10 000 cm^2
= 1 000 000 mm^2

1 sq hectometre (1 hm^2) = 10 000 m^2
= 1 hectare (1 ha)

1 sq km (1 km^2) = 1 000 000 m^2

1 ft^2 = 144 $in.^2$
1 yd^2 = 9 ft^2
1 sq mile = 640 acre = 1 section

Conversions:

1 $in.^2$ = 6.45 cm^2 = 645 mm^2
1 m^2 = 10.8 ft^2
1 acre = 0.405 ha
1 sq mile = 2.59 km^2

SI	IMPERIAL

Volume

1 m^3	=	1 000 000 cm^3	1 ft^3	=	1728 $in.^3$
	=	1 x 10^9 mm^3	1 yd^3	=	27 ft^3
1 dm^3	=	1 litre	1(liquid) U.S. gallon	=	231 $in.^3$
1 litre	=	1000 cm^3		=	4 (liquid) quarts
1 mL	=	1 cm^3	1 U.S. barrel (bbl)	=	42 U.S. gal.
1 m^3	=	1000 litres	1 imperial gallon	=	1.2 U.S. gal.

Conversions:

1 $in.^3$	=	16.4 cm^3
1 m^3	=	35.3 ft^3
1 litre	=	61 $in.^3$
1 U.S.gal	=	3.78 litres
1 U.S. bbl	=	159 litres
1 litre/s	=	15.9 U.S. gal/min

Mass and Weight

1 kilogram (1 kg)	=	1000 grams	2000 lb	=	1 ton (short)
1000 kg	=	1 tonne	1 long ton	=	2240 lb

Conversions:

1 kg (on Earth) results in a weight of 2.2 lb

Density

$$\text{mass density} = \frac{\text{mass}}{\text{volume}}$$

$$\rho = \frac{m}{V} \quad \left(\frac{kg}{m^3}\right)$$

$$\text{weight density} = \frac{\text{weight}}{\text{volume}}$$

$$\rho = \frac{w}{V} \quad \left(\frac{lb}{ft^3}\right)$$

Conversions:

(on Earth) a mass density of $1 \frac{kg}{m^3}$ results in a weight density of $0.0623 \frac{lb}{ft^3}$

SI	Imperial

RELATIVE DENSITY

In SI R.D. is a comparison of mass density to a standard. For solids and liquids the standard is fresh water.
water.

In Imperial the corresponding quantity is **specific gravity**; for solids and liquids a comparison of weight density to that of

Conversions:

In both systems the same numbers hold for R.D. as for S.G. since these are equivalent ratios.

RELATIVE DENSITY (SPECIFIC GRAVITY) OF VARIOUS SUBSTANCES

Water (fresh)	1.00	Mica	2.9
Water (sea average)	1.03	Nickel	8.6
Aluminum	2.56	Oil (linseed)	0.94
Antimony	6.70	Oil (olive)	0.92
Bismuth	9.80	Oil (petroleum)	0.76-0.86
Brass	8.40	Oil (turpentine)	0.87
Brick	2.1	Paraffin	0.86
Calcium	1.58	Platinum	21.5
Carbon (diamond)	3.4	Sand (dry)	1.42
Carbon (graphite)	2.3	Silicon	2.6
Carbon (charcoal)	1.8	Silver	10.57
Chromium	6.5	Slate	2.1-2.8
Clay	1.9	Sodium	0.97
Coal	1.36-1.4	Steel (mild)	7.87
Cobalt	8.6	Sulphur	2.07
Copper	8.77	Tin	7.3
Cork	0.24	Tungsten	19.1
Glass (crown)	2.5	Wood (ash)	0.75
Glass (flint)	3.5	Wood (beech)	0.7-0.8
Gold	19.3	Wood (ebony)	1.1-1.2
Iron (cast)	7.21	Wood (elm)	0.66
Iron (wrought)	7.78	Wood (lignum-vitae)	1.3
Lead	11.4	Wood (oak)	0.7-1.0
Magnesium	1.74	Wood (pine)	0.56
Manganese	8.0	Wood (teak)	0.8
Mercury	13.6	Zinc	7.0

Greek Alphabet

Alpha	α	Iota	ι	Rho	ρ
Beta	β	Kappa	κ	Sigma	Σ, σ
Gamma	γ	Lambda	λ	Tau	τ
Delta	Δ	Mu	μ	Upsilon	υ
Epsilon	ε	Nu	ν	Phi	Φ, ϕ
Zeta	ζ	Xi	ξ	Kai	χ
Eta	η	Omicron	O	Psi	ψ
Theta	θ	Pi	π	Omega	Ω, ω

MATHEMATICAL FORMULAE

Algebra

1. Expansion Formulae

$$(x + y)^2 = x^2 + 2xy + y^2$$

$$(x - y)^2 = x^2 - 2xy + y^2$$

$$x^2 - y^2 = (x - y)\ (x + y)$$

$$(x + y)^3 = x^3 + 3x^2y + 3xy^2 + y^3$$

$$x^3 + y^3 = (x + y)\ (x^2 - xy + y^2)$$

$$(x - y)^3 = x^3 - 3x^2y + 3xy^2 - y^3$$

$$x^3 - y^3 = (x - y)\ (x^2 + xy + y^2)$$

2. Quadratic Equation

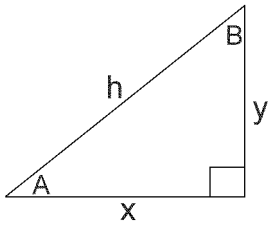
If $ax^2 + bx + c = 0$,

Then $$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Trigonometry

1. Basic Ratios

$$\text{Sin A} = \frac{y}{h}, \qquad \cos A = \frac{x}{h}, \qquad \tan A = \frac{y}{x}$$



2. Pythagoras' Law

$$x^2 + y^2 = h^2$$

3. Trigonometric Function Values

Sin is positive from 0° to 90° and positive from 90° to 180°

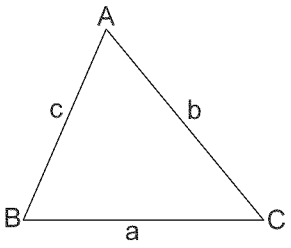
Cos is positive from 0° to 90° and negative from 90° to 180°

Tan is positive from 0° to 90° and negative from 90° to 180°

4. Solution of Triangles

a. Sine Law

$$\frac{a}{\text{Sin A}} = \frac{b}{\text{Sin B}} = \frac{c}{\text{Sin C}}$$



b. Cosine Law

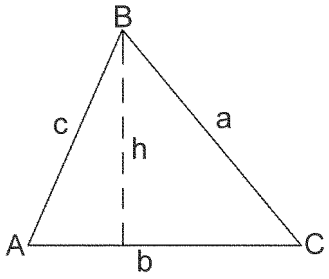
$$c^2 = a^2 + b^2 - 2\,ab\,\text{Cos C}$$

$$a^2 = b^2 + c^2 - 2\,bc\,\text{Cos A}$$

$$b^2 = a^2 + c^2 - 2\,ac\,\text{Cos B}$$

Geometry

1. Areas of Triangles



a. All Triangles

$$\text{Area} = \frac{\text{base x perpendicular height}}{2}$$

$$\text{Area} = \frac{bc \sin A}{2} = \frac{ab \sin C}{2} = \frac{ac \sin B}{2}$$

and,

$$\text{Area} = \sqrt{s\,(s-a)\,(s-b)\,(s-c)}$$

where, s is half the sum of the sides, or $s = \frac{a+b+c}{2}$

b. Equilateral Triangles

$$\text{Area} = 0.433 \times \text{side}^2$$

2. Circumference of a Circle

$$C = \pi d$$

3. Area of a Circle

$$A = \pi r^2 = \frac{\text{circumference x r}}{2} = \frac{\pi}{4} d^2 = 0.7854 d^2$$

4. Area of a Sector of a Circle

$$A = \frac{\text{arc x r}}{2}$$

$$A = \frac{\theta^\circ}{360} \times \pi r^2 \qquad (\theta = \text{angle in degrees})$$

$$A = \frac{\theta^\circ r^2}{2} \qquad (\theta = \text{angle in radians})$$