

MATHEMATICAL FORMULAS*

Quadratic Formula

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

Binomial Theorem

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

Products of Vectors

Let θ be the smaller of the two angles between \vec{a} and \vec{b} .

Then

$\vec{a} \cdot \vec{b} = \vec{b} \cdot \vec{a} = a_x b_x + a_y b_y + a_z b_z = ab \cos \theta$

$$\vec{a} \times \vec{b} = -\vec{b} \times \vec{a} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ a_x & a_y & a_z \\ b_x & b_y & b_z \end{vmatrix}$$

$$= \hat{i} \begin{vmatrix} a_y & a_z \\ b_y & b_z \end{vmatrix} - \hat{j} \begin{vmatrix} a_x & a_z \\ b_x & b_z \end{vmatrix} + \hat{k} \begin{vmatrix} a_x & a_y \\ b_x & b_y \end{vmatrix}$$

$$= (a_y b_z - b_y a_z) \hat{i} + (a_z b_x - b_z a_x) \hat{j} + (a_x b_y - b_x a_y) \hat{k}$$

$$|\vec{a} \times \vec{b}| = ab \sin \theta$$

Trigonometric Identities

$\sin \alpha \pm \sin \beta = 2 \sin \frac{1}{2}(\alpha \pm \beta) \cos \frac{1}{2}(\alpha \mp \beta)$

$\cos \alpha + \cos \beta = 2 \cos \frac{1}{2}(\alpha + \beta) \cos \frac{1}{2}(\alpha - \beta)$

*See Appendix E for a more complete list.

Derivatives and Integrals

$\frac{d}{dx} \sin x = \cos x \qquad \int \sin x \, dx = -\cos x$

$\frac{d}{dx} \cos x = -\sin x \qquad \int \cos x \, dx = \sin x$

$\frac{d}{dx} e^x = e^x \qquad \int e^x \, dx = e^x$

$\int \frac{dx}{\sqrt{x^2 + a^2}} = \ln(x + \sqrt{x^2 + a^2})$

$\int \frac{x \, dx}{(x^2 + a^2)^{3/2}} = -\frac{1}{(x^2 + a^2)^{1/2}}$

$\int \frac{dx}{(x^2 + a^2)^{3/2}} = \frac{x}{a^2(x^2 + a^2)^{1/2}}$

Cramer's Rule

Two simultaneous equations in unknowns x and y ,

$a_1x + b_1y = c_1 \quad \text{and} \quad a_2x + b_2y = c_2,$

have the solutions

$$x = \frac{\begin{vmatrix} c_1 & b_1 \\ c_2 & b_2 \end{vmatrix}}{\begin{vmatrix} a_1 & b_1 \\ a_2 & b_2 \end{vmatrix}} = \frac{c_1 b_2 - c_2 b_1}{a_1 b_2 - a_2 b_1}$$

and

$$y = \frac{\begin{vmatrix} a_1 & c_1 \\ a_2 & c_2 \end{vmatrix}}{\begin{vmatrix} a_1 & b_1 \\ a_2 & b_2 \end{vmatrix}} = \frac{a_1 c_2 - a_2 c_1}{a_1 b_2 - a_2 b_1}.$$

SI PREFIXES*

Factor	Prefix	Symbol	Factor	Prefix	Symbol
10 ²⁴	yotta	Y	10 ⁻¹	deci	d
10 ²¹	zetta	Z	10 ⁻²	centi	c
10 ¹⁸	exa	E	10 ⁻³	milli	m
10 ¹⁵	peta	P	10 ⁻⁶	micro	μ
10 ¹²	tera	T	10 ⁻⁹	nano	n
10 ⁹	giga	G	10 ⁻¹²	pico	p
10 ⁶	mega	M	10 ⁻¹⁵	femto	f
10 ³	kilo	k	10 ⁻¹⁸	atto	a
10 ²	hecto	h	10 ⁻²¹	zepto	z
10 ¹	deka	da	10 ⁻²⁴	yocto	y

*In all cases, the first syllable is accented, as in ná-no-mé-ter.

SOME PHYSICAL CONSTANTS*

Speed of light	c	$2.998 \times 10^8 \text{ m/s}$
Gravitational constant	G	$6.673 \times 10^{-11} \text{ N} \cdot \text{m}^2/\text{kg}^2$
Avogadro constant	N_{A}	$6.022 \times 10^{23} \text{ mol}^{-1}$
Universal gas constant	R	$8.314 \text{ J/mol} \cdot \text{K}$
Mass–energy relation	c^2	$8.988 \times 10^{16} \text{ J/kg}$
		931.49 MeV/u
Permittivity constant	ϵ_0	$8.854 \times 10^{-12} \text{ F/m}$
Permeability constant	μ_0	$1.257 \times 10^{-6} \text{ H/m}$
Planck constant	h	$6.626 \times 10^{-34} \text{ J} \cdot \text{s}$
		$4.136 \times 10^{-15} \text{ eV} \cdot \text{s}$
Boltzmann constant	k	$1.381 \times 10^{-23} \text{ J/K}$
		$8.617 \times 10^{-5} \text{ eV/K}$
Elementary charge	e	$1.602 \times 10^{-19} \text{ C}$
Electron mass	m_{e}	$9.109 \times 10^{-31} \text{ kg}$
Proton mass	m_{p}	$1.673 \times 10^{-27} \text{ kg}$
Neutron mass	m_{n}	$1.675 \times 10^{-27} \text{ kg}$
Deuteron mass	m_{d}	$3.344 \times 10^{-27} \text{ kg}$
Bohr radius	a	$5.292 \times 10^{-11} \text{ m}$
Bohr magneton	μ_{B}	$9.274 \times 10^{-24} \text{ J/T}$
		$5.788 \times 10^{-5} \text{ eV/T}$
Rydberg constant	R	$1.097\,373 \times 10^7 \text{ m}^{-1}$

*For a more complete list, showing also the best experimental values, see Appendix B.

THE GREEK ALPHABET

Alpha	A	α	Iota	I	ι	Rho	P	ρ
Beta	B	β	Kappa	K	κ	Sigma	Σ	σ
Gamma	Γ	γ	Lambda	Λ	λ	Tau	T	τ
Delta	Δ	δ	Mu	M	μ	Upsilon	Y	υ
Epsilon	E	ϵ	Nu	N	ν	Phi	Φ	ϕ, φ
Zeta	Z	ζ	Xi	Ξ	ξ	Chi	X	χ
Eta	H	η	Omicron	O	o	Psi	Ψ	ψ
Theta	Θ	θ	Pi	Π	π	Omega	Ω	ω

SOME CONVERSION FACTORS*

Mass and Density

$$1 \text{ kg} = 1000 \text{ g} = 6.02 \times 10^{26} \text{ u}$$

$$1 \text{ slug} = 14.59 \text{ kg}$$

$$1 \text{ u} = 1.661 \times 10^{-27} \text{ kg}$$

$$1 \text{ kg/m}^3 = 10^{-3} \text{ g/cm}^3$$

Length and Volume

$$1 \text{ m} = 100 \text{ cm} = 39.4 \text{ in.} = 3.28 \text{ ft}$$

$$1 \text{ mi} = 1.61 \text{ km} = 5280 \text{ ft}$$

$$1 \text{ in.} = 2.54 \text{ cm}$$

$$1 \text{ nm} = 10^{-9} \text{ m} = 10 \text{ Å}$$

$$1 \text{ pm} = 10^{-12} \text{ m} = 1000 \text{ fm}$$

$$1 \text{ light-year} = 9.461 \times 10^{15} \text{ m}$$

$$1 \text{ m}^3 = 1000 \text{ L} = 35.3 \text{ ft}^3 = 264 \text{ gal}$$

Time

$$1 \text{ d} = 86\,400 \text{ s}$$

$$1 \text{ y} = 365\frac{1}{4} \text{ d} = 3.16 \times 10^7 \text{ s}$$

Angular Measure

$$1 \text{ rad} = 57.3^\circ = 0.159 \text{ rev}$$

$$\pi \text{ rad} = 180^\circ = \frac{1}{2} \text{ rev}$$

Speed

$$1 \text{ m/s} = 3.28 \text{ ft/s} = 2.24 \text{ mi/h}$$

$$1 \text{ km/h} = 0.621 \text{ mi/h} = 0.278 \text{ m/s}$$

Force and Pressure

$$1 \text{ N} = 10^5 \text{ dyne} = 0.225 \text{ lb}$$

$$1 \text{ lb} = 4.45 \text{ N}$$

$$1 \text{ ton} = 2000 \text{ lb}$$

$$1 \text{ Pa} = 1 \text{ N/m}^2 = 10 \text{ dyne/cm}^2$$

$$= 1.45 \times 10^{-4} \text{ lb/in.}^2$$

$$1 \text{ atm} = 1.01 \times 10^5 \text{ Pa} = 14.7 \text{ lb/in.}^2$$

$$= 76.0 \text{ cm Hg}$$

Energy and Power

$$1 \text{ J} = 10^7 \text{ erg} = 0.2389 \text{ cal} = 0.738 \text{ ft} \cdot \text{lb}$$

$$1 \text{ kW} \cdot \text{h} = 3.6 \times 10^6 \text{ J}$$

$$1 \text{ cal} = 4.1868 \text{ J}$$

$$1 \text{ eV} = 1.602 \times 10^{-19} \text{ J}$$

$$1 \text{ horsepower} = 746 \text{ W} = 550 \text{ ft} \cdot \text{lb/s}$$

Magnetism

$$1 \text{ T} = 1 \text{ Wb/m}^2 = 10^4 \text{ gauss}$$

*See Appendix D for a more complete list.