

Essential Tool for Physics Laws, Concepts, Variables and Equations including ∞ Sample Problems, Δ Common Pitfalls and \mathcal{D} Helpful Hints

BASICS

A. Units for Physical Quantities

Base Units	Symbol	Unit
Length	L, s	Meter - m
Mass	m, M	Kilogram - kg
Temperature	T	Kelvin - K
Time	t	Second - s
Electric Current	I	Ampere - A (C/s)
Derived Units	Symbol	Unit
Acceleration	a	m/s^2
Ang. Accel.	α	radian/ s^2
Ang. Momentum	L	$kg \cdot m^2/s$
Ang. Velocity	ω	radian/sec
Angle	θ, ϕ	radian
Capacitance	C	Farad F (C/V)
Charge	Q, q, e	Coulomb C (A s)
Density	ρ	kg/m^3
Displacement	s, d, h	meter - m
Electric Field	E	V/m
Electric Flux	Φ_e	V m
Electromotive Force (EMF)	\mathcal{E}	Volt - V
Energy	E, U, K	Joule J ($kg \cdot m^2 \cdot s^{-2}$)
Entropy	S	J/K
Force	F	Newton - N ($kg \cdot m/s^2 = \text{J/m}$)
Frequency	f, ν	Hertz - Hz (cycle/s)
Heat	Q	Joule - J
Magnetic Field	B	Tesla (Wb/ m^2)
Magnetic Flux	Φ_m	Wbber Wb ($kg \cdot m^2/A \cdot s^2$)
Momentum	p	$kg \cdot m/s$
Potential	V	Voltage V (J/C)
Power	P, \mathcal{P}	Watt - W (J/s)
Pressure	P	Pascal - Pa (N/m^2)
Resistance	R	Ohm Ω (V/A)
Torque	τ	N m
Velocity	v	m/s
Volume	V	m^3
Wavelength	λ	meter - m
Work	W	Joule - J (N m)

B. Fundamental Physical Constants

Base Units	Symbol	Unit
Mass of electron	m_e	$9.11 \times 10^{-31} \text{ kg}$
Mass of proton	m_p	$1.67 \times 10^{-27} \text{ kg}$
Avogadro Constant	N_A	$6.022 \times 10^{23} \text{ mol}^{-1}$
Elementary charge	e	$1.602 \times 10^{-19} \text{ C}$
Faraday constant	F	$96,485 \text{ C/mol}$
Speed of light	c	$3 \times 10^8 \text{ m/s}$
Molar Gas Constant	R	$8.314 \text{ J mol}^{-1} \text{ K}^{-1}$
Boltzmann Constant	k	$1.38 \times 10^{-23} \text{ J K}^{-1}$
Gravitational Constant	G	$6.67 \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2}$
Permeability of Space	μ_0	$4\pi \times 10^{-7} \text{ N/A}^2$
Permittivity of Space	ϵ_0	$8.85 \times 10^{-12} \text{ F/m}$

C. Conversion factors and alternative units

Unit	Description
Angle $^\circ$ (degree)	$180^\circ = \pi \text{ rad}$
Energy Erg	CGS unit ($g \cdot cm^2/s^2$) $1 \text{ erg} = 10^{-7} \text{ J}$
Energy Electron Volt	$1 \text{ eV} = 1.602 \times 10^{-19} \text{ J}$
Force Dyne	CGS unit ($g \cdot cm/s^2 = \text{erg/cm}$) $1 \text{ dyne} = 10^{-5} \text{ N}$
Volume Liter	$1 \text{ L} = 1 \text{ dm}^3$
Pressure Bar	$1 \text{ Bar} = 10^5 \text{ Pa}$
Length Angstrom	$1 \text{ \AA} = 1 \times 10^{-10} \text{ m}$

MATHEMATICAL CONCEPTS

A. Vector Algebra

1. **Vector:** Denotes directional character using (x, y, z) components **Fig. 1**
 a. **Unit vectors:** i along x, j along y, k along z
 b. **Vector:** $A = A_x i + A_y j + A_z k$
 c. **Length of A:** $|A| = \sqrt{A_x^2 + A_y^2 + A_z^2}$
 2. **Addition of vectors A & B:** add components:
 $A + B = (A_x + B_x)i + (A_y + B_y)j + (A_z + B_z)k$
 ∞ **Sample Addition and Length Calculations:**
 $A = 3i + 4j - 3k$ $|A| = \sqrt{9 + 16 + 9} = \sqrt{34} = 5.83$
 $B = -2i + 6j + 5k$ $|B| = \sqrt{4 + 36 + 25} = \sqrt{65} = 8.06$
 $A + B = (3 - 2)i + (4 + 6)j + (-3 + 5)k$ $|A + B| = \sqrt{1 + 100 + 4} = \sqrt{105} = 10.25$
 Note: $|A| + |B| \geq |A + B|$

3. **Multiply A & B:**
 a. **Dot or scalar product:** $A \cdot B = |A||B|\cos\theta = (A_x B_x + A_y B_y + A_z B_z)$
 Note: θ is the angle between A and B;
 $A \cdot B = 0$, if $\theta = \pi/2$ **Fig. 2**
 ∞ **Sample: Scalar product:**
 $A = 3i + 4j$ $B = 3i + 5j$
 $A \cdot B = 3 \times 3 + 4 \times 5 = 9 + 20 = 29$
 $|A| = \sqrt{25} = 5$ $|B| = \sqrt{29} = 5.385$
 $\cos\theta = \frac{A \cdot B}{|A||B|} = \frac{29}{5 \times 5.385} = 0.796$
 $\theta = \cos^{-1}(0.796) = 37^\circ = 0.2 \text{ rad}$ **Fig. 3**

b. Cross or Vector Product:

$C = A \times B = |A||B|\sin\theta e$
 $\theta =$ Angle between A and B, vector e is perpendicular to A and B
 $A \times B = \begin{vmatrix} i & j & k \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$
 ∞ **Sample: Vector Product:**
 $A = 2i + j$ $B = i + 3j$
 $A \times B = \begin{vmatrix} i & j & k \\ 2 & 1 & 0 \\ 1 & 3 & 0 \end{vmatrix} = (6 - 1)k = 5k$
 - If A and B are in x-y plane, $A \times B$ is along the +z direction
 - θ is the angle formed by A & B: $\sin\theta = \frac{|C|}{|A||B|}$
 Given: $|A| = \sqrt{5}$ $|B| = \sqrt{10}$ $|C| = 5$
 $\sin\theta = \frac{5}{\sqrt{5} \times \sqrt{10}} = \frac{5}{5\sqrt{2}} = \frac{1}{\sqrt{2}}$
 $\therefore A \cdot B = 45^\circ = \pi/2 \text{ radians}$

c. The Right-Hand rule gives the orientation of vector e **Fig. 4**

D. Trigonometry

1. **Basic relations for a triangle **Fig. 5****
 $\sin \theta = \frac{y}{r}$
 $\cos \theta = \frac{x}{r}$
 $\tan \theta = \frac{y}{x} = \frac{\sin \theta}{\cos \theta}$
 $\sin^2 \theta + \cos^2 \theta = 1$
 2. **Standard Cos waves **Fig. 6****

θ rad ($^\circ$)	$\sin \theta$	$\cos \theta$	$\tan \theta$
0 (0)	0.000	1.000	0.000
$\pi/6$ (30)	0.500	0.866	0.577
$\pi/4$ (45)	0.707	0.707	1.000
$\pi/3$ (60)	0.866	0.500	1.732
$\pi/2$ (90)	1.000	0.000	∞
π (180)	0.000	-1.000	0.000



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