List of Physical Constants

Name	Symbol	Value
Gravitational Acceleration	g	9.81 m/s²
Mass of Earth	M_e	5.97×10^{24}kg
Boltzmann constant	$k_B = R/N_A$	1.381×10^{-23} J/K
Avogadro’s number	N_A	6.02×10^{23} molecules/mol
Universal gas constant	R	8.314 J/mol K
Absolute zero	0 K	– 273.15°C
Pressure conversion	1 bar	10^5 N/m^2 (or Pa)
	1 atm	$1.01\times10^5\ Pa$
Mass of electron	m_e	9.11×10^{-31} kg
Mass of proton	m_p	1.673×10^{-27} kg
Mass of neutron	m_n	1.675×10^{-27} kg
Speed of light in vacuum	c	3×10^8 m/s
Permeability of vacuum	μ_0	$4\pi\times10^{-7}\ \mathrm{T\cdot m/A}$
Permittivity of vacuum	$\varepsilon_o = 1/(\mu_o c^2)$	$8.854\times10^{-12}\ \mathrm{C^2/(N\cdot m^2)}$
Coulomb constant	$k = 1/(4\pi\varepsilon_o)$	$8.99\times10^{9}\ \mathrm{N\cdot m^2/C^2}$
Magnitude of electron charge	$\lvert e\rvert$	1.6×10^{-19} C
Gravitational constant	G	$6.67\times10^{-11}\ \mathrm{N\cdot m^2/kg^2}$
Electron volt	1 eV	1.6×10^{-19} J

List of Formulae

Part 1: Mechanics

Linear Motion

$$\vec{v}_{avg} = \frac{\Delta\vec{r}}{\Delta t} = \frac{\vec{r}_f - \vec{r}_i}{t_f - t_i}, \qquad \vec{v} \equiv \lim_{\Delta t\to0}\frac{\Delta\vec{r}}{\Delta t} = \frac{d\vec{r}}{dt}\ , \qquad v = \frac{dx}{dt}$$

$$\vec{a}_{avg} = \frac{\Delta\vec{v}}{\Delta t} = \frac{\vec{v}_f - \vec{v}_i}{t_f - t_i}, \qquad \vec{a} \equiv \lim_{\Delta t\to0}\frac{\Delta\vec{v}}{\Delta t} = \frac{d\vec{v}}{dt} = \frac{d^2\vec{r}}{dt^2}\ , \qquad a = \frac{dv}{dt}$$

$$v_f = v_i + at, \qquad x_f = x_i + \frac{1}{2}(v_i + v_f)t, \qquad v_f^2 = v_i^2 + 2a(x_f - x_i), \qquad x_f = x_i + v_i t + \frac{1}{2}at^2$$

$$y = (\tan\theta_i)x - \left(\frac{g}{2v_i^2\cos^2\theta_i}\right)x^2, \qquad h = \frac{v_i^2\sin^2\theta_i}{2g}, \qquad R = \frac{v_i^2\sin 2\theta_i}{g}$$

$\Sigma \vec{F} = \frac{d\vec{p}}{dt} = m\vec{a}, \quad F_t = v\frac{dm}{dt}, \quad \vec{p} = m\vec{v}, \quad f_k = \mu_k N, \quad f_s \leq \mu_s N, \quad v = \frac{mg}{b}(1 - e^{-\frac{b}{m}t})$

$\vec{I} = \int_{t_i}^{t_f} \vec{F} dt = \Delta\vec{p} = \vec{p}_f - \vec{p}_i, \quad \vec{I} = \vec{F}_{avg}\Delta t$

$W = \int_{x_i}^{x_f} \vec{F}.d\vec{x} = \Delta KE \quad W = \vec{F}\cdot\vec{r} = |\vec{F}||\vec{r}|\cos\phi = \Delta\mathrm{KE}, \quad P = \frac{dW}{dt} = \vec{F}\cdot\vec{v}$

$KE = \frac{1}{2}mv^2, \; PE_E = \frac{1}{2}k(\Delta x)^2, \; PE_G = mgh$

$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}, \quad v_{1i} - v_{2i} = -(v_{1f} - v_{2f})$

$\vec{r}_{CM} = \frac{1}{M}\sum_i m_i\vec{r}_i, \quad x_{CM} = \frac{1}{M}\sum_i m_ix_i, \quad y_{CM} = \frac{1}{M}\sum_i m_iy_i, \quad z_{CM} = \frac{1}{M}\sum_i m_iz_i$

Rotational Motion

$a_c = \frac{v^2}{r} = r\omega^2, \quad a_t = \frac{d|\vec{v}|}{dt}$

$s = r\theta, \quad \omega = \frac{d\theta}{dt} = \frac{v}{r}, \quad \alpha = \frac{d\omega}{dt} = \frac{a}{r},$

Gravitation

$F = \frac{GM_1M_2}{r^2} \quad U = -\frac{GM_1M_2}{r}$

$g = \frac{GM}{r^2} \quad V = -\frac{GM}{r}$

$\omega_f = \omega_i + \alpha t, \quad \theta_f = \theta_i + \frac{1}{2}(\omega_i + \omega_f)t, \quad \omega_f^2 = \omega_i^2 + 2\alpha(\theta_f - \theta_i), \quad \theta_f = \theta_i + \omega_i t + \frac{1}{2}\alpha t^2$

$I = \sum_i r_i^2 m_i, \quad I = \int r^2 dm, \quad I_0 = I_{CM} + MD^2, \quad I_z = I_x + I_y$

$\tau = \vec{r}\times\vec{F} = |\vec{F}||\vec{r}|\sin\phi, \quad \Sigma\tau = \frac{dL}{dt} = I\alpha, \quad KE_r = \frac{1}{2}I\omega^2, \quad L = \vec{r}\times\vec{p} = |\vec{p}||\vec{r}|\sin\phi = I\omega$

List of moments of inertia

Thin cylindrical shell	$I_{CM} = MR^2$
Hollow cylinder	$I_{CM} = \frac{1}{2}M(R_1^2 + R_2^2)$
Solid cylinder or disc	$I_{CM} = \frac{1}{2}MR^2$
Rectangular plate	$I_{CM} = \frac{1}{12}M(a^2 + b^2)$
Long thin rod with rotation axis through centre	$I_{CM} = \frac{1}{12}ML^2$
Long thin rod with rotation axis through end	$I = \frac{1}{3}ML^2$
Thin spherical shell	$I_{CM} = \frac{2}{3}MR^2$
Solid sphere	$I_{CM} = \frac{2}{5}MR^2$

Part 2: Thermal Physics

$\Delta L = \alpha L_i \Delta T$, $\Delta A = 2\alpha A_i \Delta T$, $\Delta V = \beta V_i \Delta T$

$$T = \frac{P(T) - P(0)}{P(100) - P(0)} \times 100, \quad T = 273.16\,K \lim_{P_{tr} \to 0} \frac{P}{P_{tr}},$$

$PV = nRT$, $PV^{\gamma} = \text{constant}$, $TV^{\gamma-1} = constant$, $\gamma = \frac{c_p}{c_v}$, $c_p - c_v = R$, $k_B = \frac{R}{N_A}$

$$KE_{total} = \frac{1}{2} M\overline{v^2} = \frac{3}{2} nRT = \frac{3}{2} Nk_B T, \quad E_{int} = \frac{3}{2} nRT$$

$Q = mc\Delta T$, $Q = ml$, $Q = nC_V \Delta T$, $Q = nC_P \Delta T$ $Q = \Delta E_{int} + W$

$$W = \int_{V_i}^{V_f} PdV, \quad W = p(V_f - V_i), \quad W = nRTln\frac{V_f}{V_i}, \quad W = \frac{1}{1-\gamma}\left(p_f V_f - p_i V_i\right)$$

$$\eta = \frac{W_{out}}{Q_H} = 1 - \frac{Q_C}{Q_H}$$

Part 3: Electricity and Magnetism

$\vec{A}.\vec{B} \equiv |A||B|\cos\theta$; $\vec{A} \times \vec{B} \equiv |A||B|\sin\theta\ \hat{n}$

$\vec{F} = q\vec{E}$ $\quad |F| = \frac{|Qq|}{4\pi\epsilon_o r^2}$ $\quad |E| = \frac{|Q|}{4\pi\epsilon_o r^2}$ $\quad \Phi_E = \oint \vec{E}.d\vec{A} = \frac{Q_{in}}{\epsilon_o}$

$U = qV$ $\quad U = \frac{Qq}{4\pi\epsilon_o r}$ $\quad V = \frac{Q}{4\pi\epsilon_o r}$ $\quad E_r = -\frac{dV}{dr}$

$Q = C\Delta V$ $\quad U = \frac{1}{2}C(\Delta V)^2$ $\quad u_E = \frac{1}{2}\epsilon_o E^2$ $\quad \vec{\tau} = \vec{p} \times \vec{E}$;

$C = \frac{\epsilon_o A}{d}$ $\quad U = -\vec{p}.\vec{E}$

$I = \frac{dQ}{dt}$ $\quad J = \frac{I}{A} = nqv_d$ $\quad J = \sigma E$ $\quad V = IR$; $R = \varrho\frac{l}{A}$; $\varrho = \frac{1}{\sigma}$

$\mathcal{E} = IR + Ir$ $\quad q(t) = Q(1 - e^{-\frac{t}{RC}})$ $\quad q(t) = Q_o e^{-\frac{t}{RC}}$ $\quad \sum_{junction} I = 0$; $\sum_{\substack{closed\\loop}} \Delta V = 0$

$I(t) = \frac{\mathcal{E}}{R} e^{-\frac{t}{RC}}$ $\quad P = IV = I^2 R = \frac{V^2}{R}$

$\vec{F} = q\vec{v} \times \vec{B}$ $\quad \vec{B} = \frac{\mu_o}{4\pi}\int \frac{I\, d\vec{s} \times \hat{r}}{r^2}$ $\quad \oint \vec{B}.d\vec{s} = \mu_o I$ $\quad B = \frac{\mu_o I}{2\pi r}$; $B = \mu_o nI$; $B = \frac{\mu_o NI}{2r}$

$\vec{F} = I\vec{L} \times \vec{B}$ $\quad \vec{F} = I\int_a^b d\vec{s} \times \vec{B}$ $\quad \Phi_B = \oint \vec{B}.d\vec{A} = 0$ $\quad u_B = \frac{1}{2\mu_o}B^2$

$$\vec{F} = q\vec{E} + q\vec{v} \times \vec{B} \qquad \vec{\tau} = \vec{\mu} \times \vec{B}; U = -\vec{\mu}.\vec{B}$$

$$\mathcal{E} = -N\frac{d\Phi_B}{dt} \qquad \Phi_B = \int \vec{B}.d\vec{A} \qquad \mathcal{E} = Blv\cos\theta \qquad \oint \vec{E}.d\vec{s} = -\frac{d\Phi_B}{dt}$$

$$\mathcal{E} = -L\frac{dI}{dt} \qquad L = \frac{N\Phi_B}{I};\ \mathrm{U} = \frac{1}{2}LI^2 \qquad \mathcal{E}_2 = -M_{12}\frac{dI_1}{dt} \qquad M_{12} = \frac{N_2\Phi_{12}}{I_1} = M_{21} = \frac{N_1\Phi_{21}}{I_2}$$

$$I(t) = \frac{\mathcal{E}}{R}e^{-\frac{R}{L}t} \qquad I(t) = \frac{\mathcal{E}}{R}(1 - e^{-\frac{R}{L}t}) \qquad Q = Q_{max}e^{-\frac{R}{2L}t}\cos\omega_d t \qquad \omega_d = \sqrt{\frac{1}{LC} - (\frac{R}{2L})^2}$$

$$I_{rms} = \frac{I_{max}}{\sqrt{2}} \qquad P_{avg} = I_{rms}^2 R$$

Part 4: Mathematics

Algebra

$a^m \times a^n = a^{m+n}$ $\quad (a^m)^n = a^{mn}$ $\quad x_{1,2} = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$ where $ax^2 + bx + c = 0$

Trigonometric Identities

$\tan A = {\sin A}/{\cos A}$ $\quad \sec A = {1}/{\cos A}$ $\quad \mathrm{cosec}\, A = {1}/{\sin A}$ $\quad \cot A = {\cos A}/{\sin A} = {1}/{\tan A}$

$\sin^2 A + \cos^2 A = 1$ $\quad \sec^2 A = 1 + \tan^2 A$ $\quad \mathrm{cosec}^2 A = 1 + \cot^2 A$

$\frac{a}{\sin\alpha} = \frac{b}{\sin\beta} = \frac{c}{\sin\gamma}$ & $c^2 = a^2 + b^2 - 2ab\cos\gamma$ where $\alpha + \beta + \gamma = 180°$

Derivatives / Integrals (An arbitrary constant should be added to each integral)

$\frac{d}{dx}(ax^n) = anx^{n-1}$ $\quad \frac{d}{dx}(e^{ax}) = ae^{ax}$

$\frac{d}{dx}(\sin kx) = k\cos kx$ $\quad \frac{d}{dx}(\cos kx) = -k\sin kx$ $\quad \frac{d}{dx}(\tan kx) = k\sec^2 kx$

$\int x^n dx = \frac{x^{n+1}}{n+1}\ (n \neq 1)$ $\quad \int \frac{dx}{x} = \ln x$ $\quad \int \frac{dx}{a+x} = \ln(a+x)$ $\quad \int \frac{xdx}{a+x} = \mathrm{x} - a\ln(a+x)$

$\int \frac{dx}{\sqrt{x^2 \pm a^2}} = \ln\left(x + \sqrt{x^2 \pm a^2}\right)$ $\quad \int \frac{xdx}{\sqrt{x^2 \pm a^2}} = \sqrt{x^2 \pm a^2}$

$\int \frac{dx}{(x^2 \pm a^2)^{3/2}} = \frac{\pm x}{a^2\sqrt{x^2 \pm a^2}}$ $\quad \int \frac{xdx}{(x^2 \pm a^2)^{3/2}} = \frac{-1}{\sqrt{x^2 \pm a^2}}$