Physics Formula Sheet

Your Name

2023/ 2024

Constants

Constant	Symbol	Value
Speed of light	c	3.00×10^{8} m/s
Gravitational constant	G	6.674×10^{-11} N(m/kg)^2
Planck's constant	h	6.626×10^{-34} J.s
Mass of the electron	m_e	9.10939×10^{-31} kg
Mass of the proton	m_p	1.67262×10^{-27} kg
Charge of the electron	$-e$	-1.60218×10^{-19} C
Permittivity of free space	ϵ_0	8.85419×10^{-12} C^2/J m
Boltzmann constant	k_B	1.38066×10^{-23} J/ K
Avogadro's constant	N_A	6.022×10^{23} 1/mol

Classical Physics

Title	**Equation**
Bragg's Reflection	$n\lambda = 2d\sin(\theta)$
Diffraction (Single Slit)	$\lambda = d\sin(\theta)$
Young's Double Slit	$\frac{\Delta x}{L} = \frac{\lambda}{d} \approxeq \sin\theta$
Heat Transfer (Fourier's Law)	$Q = mC_v\Delta T$
Continuity Equation	$\nabla \cdot J = -\frac{d\rho}{dt}$
Force of Gravity	$F = G\frac{m_1 m_2}{r^2}$
Coulomb Force	$F = \frac{q_1 q_2}{4\pi\epsilon_0 r^2}$
Special Relativity (Time Dilation)	$E^2 = (pc)^2 + (m_0c^2)^2$

Nuclear and magnetic physics

Magnetic Field	: $E_B = -\mu B$, $\mu = \frac{e}{2m}L$ $F_z = -\frac{\partial V}{\partial z} = \mu\frac{\partial B}{\partial z}$
Rigid rotator	: $E_{\text{rot}} = \frac{\mathbf{L}^2}{2I}$ $I = \frac{m_1 m_2}{m_1+m_2}R^2$
Radioactive decay	$N(t) = N(0)\exp^{-\lambda t} = N(0)(\frac{1}{2})^{t/\tau_{1/2}}$ $\tau_{1/2} = \ln(2)/\lambda$

Thermodynamics

Black body:

$$D(k)dk = \frac{\partial N(k)}{\partial k}\frac{dk}{V} = \frac{k^2}{\pi^2}dk$$

$$D(\omega)d\omega = \frac{\omega^2}{\pi^2 c^3}d\omega$$

$$u(\omega)d\omega = \frac{\omega^2}{\pi^2 c^3}k_B T d\omega \text{ classical limit}$$

$$u(\omega)d\omega = \frac{\hbar\omega^3}{\pi^2 c^3}\frac{1}{\exp(\frac{\hbar\omega}{k_B T}) - 1}d\omega$$

$$I(\omega) = cu(\omega)d\omega$$

Quantum Mechanics

$$\text{Time-dependent Schrodinger's Equation} : i\hbar\frac{\partial}{\partial t}\Psi(\vec{x}, t) = [-\frac{\hbar^2}{2m}(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}) + V(x)]$$

$$\text{Energy of a photon} : E = hf$$

$$\text{Time-independent Schrodinger's Equation} : E\phi = \hat{H}\phi = \Big(-\frac{\hbar^2}{2m}\nabla^2 + V(x)\Big)\cdot\phi$$

$$\text{Energy of a photon} : E = hf$$

$$\text{Infinite potential well} E_n = \frac{\hbar^2}{2m}k_n^2 = \frac{\hbar^2\pi^2 n^2}{2mL^2} = n^2 E_0,\ \ \psi_n(x) = \sqrt{\frac{2}{L}}\sin(\frac{n\pi x}{L}),\ \ E_0 = \frac{\hbar^2\pi^2}{2mL^2}$$

Mathematical equations

Trigonometric functions:

$$\int \sin^n ax dx = -\frac{1}{a}\cos ax\ {}_2F_1\left[\frac{1}{2}, \frac{1-n}{2}, \frac{3}{2}, \cos^2 ax\right]$$

$$\int \sin^2 ax dx = \frac{x}{2} - \frac{1}{4a}\sin 2ax + C \tag{1}$$

$$\int x\sin^2 ax dx = \frac{x^2}{4} - \frac{x}{4a}\sin 2ax - \frac{1}{8a^2}\cos 2ax + C \tag{2}$$

$$\int x^2\sin^2 xax dx = \frac{x^3}{6} - (\frac{x^2}{4a} - \frac{1}{8a^3})\sin 2ax - \frac{x}{4a^2}\cos 2ax + C \tag{3}$$

$$\int \tan ax dx = -\frac{1}{a}\ln|\cos ax| + C = \frac{1}{a}\ln|\sec ax| + C \tag{4}$$

$$\int \frac{\cos ax}{x}dx = \ln|ax| + \sum_1^\infty (-)^k\frac{(ax)^{2k}}{2k(2k)!} + C \tag{5}$$

$$\int \cos^2 ax dx = \frac{x}{2} + \frac{1}{4a}\sin 2ax + C \tag{6}$$

$$\int \sin^3 ax dx = \frac{\cos 3ax}{12a} - \frac{3\cos ax}{4a} + C \tag{7}$$

$$\int \tan^2 x dx = \tan x - x + C \tag{8}$$

$$\int \sin ax\cos ax dx = -\frac{\cos^2 ax}{2a} + C \tag{9}$$

$$\int x\cos ax dx = \frac{\cos ax}{a^2} + \frac{x\sin ax}{a} + C \tag{10}$$

$$\int \cos ax dx = \frac{1}{a}\sin ax + C \tag{11}$$

$$\int x \sin ax dx = \frac{\sin ax}{a^2} - \frac{x \cos ax}{a} + C \tag{12}$$

$$\int (\sin ax)(\cos^n ax) dx = -\frac{1}{a(n+1)}\cos^{n+1} ax + C \tag{13}$$

Exponential functions:

$$\int_{-\infty}^{\infty} e^{-ax^2}\,\mathrm{d}x = \frac{\sqrt{\pi}}{\sqrt{a}}\ (a > 0) \tag{14}$$

$$\int_{-\infty}^{\infty} xe^{-ax^2+bx}\,\mathrm{d}x = \frac{\sqrt{\pi}b}{2a^{3/2}}e^{\frac{b^2}{4a}}\ (\Re(a) > 0) \tag{15}$$

$$\int_{-\infty}^{\infty} x^n e^{-ax}\,\mathrm{d}x = \begin{cases} \frac{\Gamma(n+1)}{a^{n+1}}\ (n > -1, a > 0) \\ \frac{n!}{a^{n+1}}\ (n = 0, 1, 2, ..., a > 0) \end{cases} \tag{16}$$

$$\int_{-\infty}^{\infty} x^2 e^{-ax^2}\ dx = \frac{1}{2}\sqrt{\frac{\pi}{a^3}}\ (a > 0) \tag{17}$$

$$\int xe^{cx} dx = \left(\frac{x}{c} - \frac{1}{c^2}\right)e^{cx} \tag{18}$$

$$\int x^2 e^{cx} dx = \left(\frac{x^2}{c} - \frac{2x}{c^2} + \frac{2}{c^3}\right)e^{cx} \tag{19}$$

$$\int x^4 e^{-ax^2} dx = \sqrt{\frac{\pi}{a}}\frac{3}{4a^2} \tag{20}$$

Spherical coordinates

$$x = r\sin\theta\cos\phi$$
$$y = r\sin\theta\sin\phi$$
$$z = r\cos\phi$$

Volume fraction:

$$dV = r^2 \sin\theta dr d\theta d\phi$$

Solid angle:

$$d\Omega = \frac{dS_r}{r^2} = \sin\theta d\theta d\phi$$

Surface element:

$$dS_r = r^2 \sin\theta d\theta d\phi$$

$$\nabla f = \frac{\partial f}{\partial r}\vec{r} + \frac{1}{r}\frac{1}{r\sin\theta}\frac{\partial f}{\partial\phi}\vec{\phi} \tag{21}$$

$$\operatorname{div}\mathbf{F} = \nabla\cdot\mathbf{F} = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2 F_r\right) + \frac{1}{r\sin\theta}\frac{\partial}{\partial\theta}(\sin\theta\, F_\theta) + \frac{1}{r\sin\theta}\frac{\partial F_\varphi}{\partial\varphi}. \tag{22}$$

$$\begin{aligned} \nabla\times\mathbf{F} = \frac{1}{r\sin\theta}(\frac{\partial}{\partial\theta}(A_\phi\sin\theta) - \frac{\partial A_\theta}{\partial\phi})\vec{r} \\ + \frac{1}{r}(\frac{1}{\sin\theta}\frac{\partial A_r}{\partial\phi} - \frac{\partial}{\partial r}(rA_\phi))\vec{\theta} \\ + \frac{1}{r}(\frac{\partial}{\partial r}(rA_\phi) - \frac{\partial A_r}{\partial\phi})\vec{\phi} \end{aligned} \tag{23}$$

$$\begin{aligned} \nabla^2 f = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial f}{\partial r}\right) + \frac{1}{r^2 \sin\theta}\frac{\partial}{\partial\theta}\left(\sin\theta\frac{\partial f}{\partial\theta}\right) + \frac{1}{r^2\sin^2\theta}\frac{\partial^2 f}{\partial\varphi^2} = \\ (\frac{\partial^2}{\partial r^2} + \frac{2}{r}\frac{\partial}{\partial r})f + \frac{1}{r^2\sin\theta}\frac{\partial}{\partial\theta}(\sin\theta\frac{\partial}{\partial\theta})f + \frac{1}{r^2\sin^2\theta}\frac{\partial^2}{\partial\phi^2}f \end{aligned} \tag{24}$$

Periodic Table

Insert or link to a detailed periodic table here.