

$$\begin{aligned}\sin(a+b) &= \sin a \cos b + \sin b \cos a \\ \cos(a+b) &= \cos a \cos b - \sin a \sin b \\ \sin(-x) &= -\sin x & \left| \begin{array}{l} \sin(\pi/2 - x) = \cos x \\ \cos(\pi/2 - x) = \sin x \end{array} \right. \\ \cos(-x) &= \cos x \\ \sin^2 x + \cos^2 x &= 1 & \left| \begin{array}{l} 2i \sin x = e^{ix} - e^{-ix} \\ 2 \cos x = e^{ix} + e^{-ix} \end{array} \right. \\ e^{ix} &= \cos x + i \sin x \\ \cosh^2 x - \sinh^2 x &= 1 & \left| \begin{array}{l} 2 \sinh x = e^x - e^{-x} \\ 2 \cosh x = e^x + e^{-x} \end{array} \right. \\ e^x &= \cosh x + \sinh x \\ \cos(2x) &= 1 - 2 \sin^2 x = 2 \cos^2 x - 1 \\ \sin(nx) &= 2 \cos x \sin((n-1)x) - \sin((n-2)x) \\ \cos(nx) &= 2 \cos x \cos((n-1)x) - \cos((n-2)x)\end{aligned}$$

$$\begin{aligned}s_n &= a_1 + \dots + a_n \\ a_k &= k & \left| \begin{array}{l} s_n = (n/2)(n+1) \\ s_n = (n/6)(n+1)(2n+1) \\ s_n = (n/2)^2(n+1)^2 \end{array} \right. \\ a_k &= k^2 \\ a_k &= k^3 \\ \sum_{k=a}^{b-1} q^k &= \frac{q^b - q^a}{q - 1}, \quad \sum_{k=a}^{b-1} k^m q^k = \left(q \frac{d}{dq}\right)^m \frac{q^b - q^a}{q - 1} \\ e^x &= \sum_{k=0}^{\infty} \frac{x^k}{k!}, \quad \frac{x}{e^x - 1} = \sum_{k=0}^{\infty} \bar{B}_k \frac{x^k}{k!}, \quad \frac{1}{1-x} = \sum_{k=0}^{\infty} x^k\end{aligned}$$

$$\begin{aligned}e^x &= \lim_{n \rightarrow \infty} \left(1 + \frac{x}{n}\right)^n, \quad \ln x = \lim_{h \rightarrow 0} \frac{x^h - 1}{h} \\ \ln(1-x) &= (-1) \sum_{k=1}^{\infty} \frac{x^k}{k} \quad (-1 \leq x < 1) \\ \sin x &= \sum_{k=0}^{\infty} (-1)^k \frac{x^{2k+1}}{(2k+1)!} & \left| \begin{array}{l} \sinh x = \sum_{k=0}^{\infty} \frac{x^{2k+1}}{(2k+1)!} \\ \cosh x = \sum_{k=0}^{\infty} \frac{x^{2k}}{(2k)!} \end{array} \right. \\ \cos x &= \sum_{k=0}^{\infty} (-1)^k \frac{x^{2k}}{(2k)!}\end{aligned}$$

$$\begin{aligned}(x+1)^n &= \sum_{k=0}^{\infty} \binom{n}{k} x^k \quad (|x| < 1) \\ \frac{1}{(1-x)^n} &= \sum_{k=0}^{\infty} \binom{n+k-1}{k} x^k \quad (|x| < 1)\end{aligned}$$

$$x_{n+1} = \varphi(x_n), \quad \varphi(x) = x - f(x)/f'(x)$$

$$f(x+h) \stackrel{??}{=} \sum_{k=0}^{\infty} \frac{\langle h, \nabla \rangle^k}{k!} f(x) = e^{\langle h, \nabla \rangle} f(x)$$

$$n! \approx \sqrt{2\pi n} (n/e)^n$$

$$n! \approx \sqrt{2\pi n} n^n \exp\left(\frac{1}{12n} - n\right)$$

$$\begin{aligned}\sin' x &= \cos x & \left| \begin{array}{l} (fg)' = f'g + g'f \\ (f/g)' = (f'g - g'f)/g^2 \\ (1/g)' = -g'/g^2 \\ (f(g))' = f'(g)g' \\ (e^x)' = e^x \\ \ln' x = 1/x \\ (x^n)' = nx^{n-1} \end{array} \right. \\ \cos' x &= -\sin x \\ \tan' x &= 1 + \tan^2 x \\ \cot' x &= -1 - \cot^2 x \\ \arcsin' x &= 1/\sqrt{1-x^2} \\ \arccos' x &= -1/\sqrt{1-x^2} \\ \arctan' x &= 1/(x^2+1)\end{aligned}$$

$$\begin{aligned}t = \tan(x/2) & \left| \begin{array}{l} \sin x = \frac{2t}{1+t^2} \\ \cos x = \frac{1-t^2}{1+t^2} \end{array} \right. \\ dx &= \frac{2 dt}{1+t^2}\end{aligned}$$

$$\begin{aligned}f(x) &= f(2a-x) \quad (\text{Achsensymmetrie}) \\ f(x) &= 2b - f(2a-x) \quad (\text{Punktsymmetrie})\end{aligned}$$

$$\begin{aligned}p(x) &= y_0 + a_1(x-x_0) + a_2(x-x_0)(x-x_1) \\ a_1 &= \frac{y_1-y_0}{x_1-x_0}, \quad a_2 = \frac{1}{x_2-x_1} \left( \frac{y_2-y_0}{x_2-x_0} - a_1 \right)\end{aligned}$$

$$\begin{aligned}\int_a^b f(x) dx &= \lim_{n \rightarrow \infty} \sum_{k=1}^n f\left(a + k \frac{b-a}{n}\right) \frac{b-a}{n} \\ \int_a^b fg' dx &= [fg]_a^b - \int_a^b f'g dx \\ \int_a^b f(g)g' dx &= \int_{g(a)}^{g(b)} f(u) du \\ \frac{d}{dx} \int_{a(x)}^{b(x)} f(x,t) dt &= \int_{a(x)}^{b(x)} \frac{\partial}{\partial x} f(x,t) dt + g(x) \\ g(x) &= f(x, b(x))b'(x) - f(x, a(x))a'(x)\end{aligned}$$

$$\int_{\varphi(U)} f(\underline{x}) d\underline{x} = \int_U f(\varphi(\underline{u})) |\det D\varphi(\underline{u})| d\underline{u}$$

$$\begin{aligned}T(x) &= f(x_0) + f'(x_0)(x-x_0) \\ N(x) &= f(x_0) - \frac{1}{f'(x_0)}(x-x_0)\end{aligned}$$

$$(n+1)! = (n+1)n!$$

$$\binom{n}{k} = \frac{n!}{k!(n-k)!}$$

$$n! = \Gamma(n+1)$$

$$\Gamma(x+1) = x\Gamma(x)$$

$$\Gamma(x)\Gamma(1-x) = \frac{\pi}{\sin(\pi x)}$$

$$\begin{aligned}x &= r \cos \varphi & \left| \begin{array}{l} r = \sqrt{x^2 + y^2} \\ \varphi = \operatorname{sgn}(y) \arccos(x/r) \end{array} \right. \\ y &= r \sin \varphi\end{aligned}$$

$$\det J = r \quad (\text{polar, Zylinder})$$

$$\det J = r^2 \sin \theta \quad (\text{Kugel})$$

$$\operatorname{grad}(fg) = g \operatorname{grad} f + f \operatorname{grad} g$$

$$\operatorname{div}(fv) = v \operatorname{grad} f + f \operatorname{grad} v$$

$$\operatorname{rot}(fv) = f \operatorname{rot} v - v \times \operatorname{grad} f$$

$$\operatorname{rot} \operatorname{rot} v = \operatorname{grad} \operatorname{div} v - \Delta v$$

$$\operatorname{div}(v \times w) = w \operatorname{rot} v - v \operatorname{rot} w$$

$$\operatorname{rot} \operatorname{grad} f = 0$$

$$\operatorname{div} \operatorname{rot} v = 0$$

$$\begin{bmatrix} a & b \\ c & d \end{bmatrix}^{-1} = \frac{1}{ad-bc} \begin{bmatrix} d & -b \\ -c & a \end{bmatrix}$$

$$R(\varphi) = \begin{bmatrix} \cos \varphi & -\sin \varphi \\ \sin \varphi & \cos \varphi \end{bmatrix}$$

$$\begin{bmatrix} a_1 \\ a_2 \\ a_3 \end{bmatrix} \times \begin{bmatrix} b_1 \\ b_2 \\ b_3 \end{bmatrix} = \begin{bmatrix} a_2 b_3 - a_3 b_2 \\ a_3 b_1 - a_1 b_3 \\ a_1 b_2 - a_2 b_1 \end{bmatrix}$$

$$L\{f(t)\} = \int_0^{\infty} f(t) e^{-pt} dt$$

$$F\{f(t)\} = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} f(t) e^{-i\omega t} dt$$

$$Z\{a_n\} = \sum_{k=0}^{\infty} a_k z^{-k}$$

$$y = \bar{y} + \frac{s_{xy}}{s_x}(x - \bar{x})$$

$$\nabla f(x, y) + \lambda \nabla g(x, y) = 0$$

$$I[y] = \int_a^b F(x, y(x), y'(x)) dx$$

$$\frac{\partial F}{\partial y} = \frac{d}{dx} \frac{\partial F}{\partial y'}, \quad \frac{\partial L}{\partial q} = \frac{d}{dt} \frac{\partial L}{\partial \dot{q}}, \quad \frac{\partial \mathcal{L}}{\partial \varphi} = \partial_{\mu} \frac{\partial \mathcal{L}}{\partial (\partial_{\mu} \varphi)}$$

## Mechanik

$$\begin{array}{l|l} v = s'(t) & \omega = \varphi'(t) \\ a = v'(t) & \alpha = \omega'(t) \\ F = p'(t) & L = M'(t) \\ p = mv & L = J\omega \\ F = ma & M = J\alpha \\ E_{\text{kin}} = \frac{1}{2}mv^2 & E_{\text{rot}} = \frac{1}{2}J\omega^2 \end{array}$$

$$\begin{array}{l|l|l} s = \varphi r & M = rF & E_{\text{pot}} = mgh \\ v = \omega r & M = r \times F & E_{\text{kin}} + E_{\text{pot}} = \text{const.} \\ a = \alpha r & L = r \times p & F = Ds \quad (\text{Feder}) \end{array}$$

## Gleichstrom

$$\begin{array}{l|l|l} U = RI & Q = It & GR = 1 \\ I = GU & W = Pt & \\ P = UI & W = QU & \end{array}$$

## Wechselstrom

$$\begin{array}{l|l|l} \underline{U} = \underline{ZI} & \underline{Z} = R + jX & Z^2 = R^2 + X^2 \\ \underline{I} = \underline{YU} & \underline{Y} = G + jQ & R = Z \cos \varphi \\ \underline{S} = \underline{UI} & \underline{S} = P + jB & X = Z \sin \varphi \end{array}$$

$$\begin{array}{l|l|l} \underline{Z} = R & \text{Widerstand} & \omega = 2\pi f \\ \underline{Z} = jX_C & \text{Kondensator} & X_C = -1/(\omega C) \\ \underline{Z} = jX_L & \text{Spule} & X_L = \omega L \end{array}$$

$$\begin{array}{l|l} u_s = \sqrt{2} U_{\text{eff}} & u = u_s \sin(\omega t + \varphi_0) \\ i_s = \sqrt{2} I_{\text{eff}} & i = i_s \sin(\omega t + \varphi_0) \end{array}$$

## allgemeine Gleichungen

$$\begin{array}{l|l} u = Ri & p = ui \\ i = Cu'(t) & \\ u = Li'(t) & \end{array}$$

## elektrostatisches Feld

$$F = \frac{1}{4\pi\epsilon} \frac{Q_1 Q_2}{r^2} \quad \left| \quad \vec{F}_1 = \frac{1}{4\pi\epsilon} Q_1 Q_2 \frac{\underline{x}_1 - \underline{x}_2}{|\underline{x}_1 - \underline{x}_2|^3} \right.$$

$$\begin{array}{l|l|l} \vec{F} = q\vec{E} & Q = CU & U = \varphi(B) - \varphi(A) \\ \underline{D} = \epsilon \underline{E} & \epsilon = \epsilon_0 \epsilon_r & W = QU \\ \underline{E} = -\text{grad } \varphi & & \\ \epsilon_0 E^2 = 2w_e & & \end{array}$$

## Plattenkondensator

$$U = Ed \quad | \quad C = \epsilon A/d$$

## homogenes Feld in der Spule

$$Hl = NI \quad | \quad Bl = \mu NI \quad | \quad \Theta = NI$$

## magnetostatisches Feld

$$\begin{array}{l|l} \vec{F} = q\vec{v} \times \underline{B} & \Phi = BA \\ F = qvB & \underline{B} = \mu \underline{H} \\ F = BI l & \mu = \mu_0 \mu_r \end{array}$$

$$H = I/(2\pi r) \quad (\text{Feld um einen geraden Leiter}) \\ B^2 = 2\mu_0 w_m$$

## Elektrodynamik

$$\begin{array}{l} E = -\nabla\varphi \\ \epsilon\Delta\varphi = -\rho(x) \\ \epsilon_0 E^2 = 2w_e \\ B^2 = 2\mu_0 w_m \end{array}$$

## Maxwell-Gleichungen

$$\begin{array}{l|l} \langle \nabla, D \rangle = \rho_f(x) & \langle \nabla, \epsilon_0 E \rangle = \rho(x) \\ \langle \nabla, B \rangle = 0 & \langle \nabla, B \rangle = 0 \\ \nabla \times E = -D_t B & \nabla \times E = -D_t B \\ \nabla \times H = J_f + D_t D & \nabla \times B = \mu_0(J + \epsilon_0 D_t E) \end{array}$$

## SRT

$$\begin{array}{l} \gamma = \frac{1}{\sqrt{1-\beta^2}}, \quad \beta = v/c \\ \gamma = \cosh \varphi, \quad \beta\gamma = \sinh \varphi, \quad \beta = \tanh \varphi \\ ct' = \gamma(ct - \beta x), \quad x' = \gamma(x - vt), \quad (y, z)' = (y, z) \\ t = \gamma\tau \quad \left| \quad \begin{array}{l} E_{\text{kin}} = E - E_0 \\ E_{\text{kin}} = \gamma mc^2 - mc^2 \\ E^2 = (pc)^2 + (mc^2)^2 \end{array} \right. \\ p = \gamma mv \\ E = \gamma mc^2 \end{array}$$

$$\Lambda_v = \begin{bmatrix} \gamma & -\beta\gamma & 0 & 0 \\ -\beta\gamma & \gamma & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{array}{l} g = \text{diag}(1, -1, -1, -1) \\ (D_\mu) = (D_{ct}, D_x, D_y, D_z) \\ (D^\mu) = (D_{ct}, -D_x, -D_y, -D_z) \end{array}$$

## Optik

$$\frac{1}{f} = \frac{1}{g} + \frac{1}{b}, \quad A = \frac{B}{G} = \frac{b}{g}$$

$$n_1 \sin(\varphi_1) = n_2 \sin(\varphi_2)$$

$$c_0 = nc$$

## Thermodynamik

$$\begin{array}{l|l|l} R = N_A k_B & m = nM & V = nV_m \\ R = R_s M & m = Nm_T & N = nN_A \end{array}$$

$$\begin{array}{l} pV = nRT \\ \frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2} \\ Q = mc\Delta T \end{array}$$

## Konstanten

$$\epsilon_0 = 8.8542 \times 10^{-12} \text{ C/(V m)}$$

$$\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$$

$$c_0 = 2.9979 \times 10^8 \text{ m/s}$$

$$e = 1.6022 \times 10^{-19} \text{ C}$$

$$G = 6.674 \times 10^{-11} \text{ m}^3/(\text{kg s}^2)$$

$$N_A = 6.0221 \times 10^{23} \text{ mol}^{-1}$$

$$k_B = 1.3806 \times 10^{-23} \text{ J/K}$$

$$R = 8.3145 \text{ J/(mol K)}$$

$$0 \text{ K} = -273.15 \text{ }^\circ\text{C}$$

$$u = 1.6605 \times 10^{-27} \text{ kg}$$

$$h = 6.6261 \times 10^{-34} \text{ Js}$$

$$\hbar = 1.0546 \times 10^{-34} \text{ Js}$$

$$\sigma = 5.6704 \times 10^{-8} \text{ W/(m}^2\text{K}^4)$$

$$m_e = 9.1094 \times 10^{-31} \text{ kg}$$

$$m_p = 1.6726 \times 10^{-27} \text{ kg}$$

$$m_n = 1.6749 \times 10^{-27} \text{ kg}$$

$$m_\alpha = 6.6447 \times 10^{-27} \text{ kg}$$