Winkelfunktionen

$\sin(x+y) = \sin x \cos y + \cos x \sin y$ | $\sin(z \pm \pi) = -\sin z$

$\sin(x-y) = \sin x \cos y - \cos x \sin y$ | $\cos(z \pm \pi) = -\cos z$

$\cos(x+y) = \cos x \cos y - \sin x \sin y$ | $\sin(\pi/2 - x) = \cos x$

$\cos(x-y) = \cos x \cos y + \sin x \sin y$ | $\cos(\pi/2 - x) = \sin x$

$\sin(nx) = 2\cos x \sin((n-1)x) - \sin((n-2)x)$ | $\sin(-z) = -\sin z$

$\cos(nx) = 2\cos x \cos((n-1)x) - \cos((n-2)x)$ | $\cos(-z) = \cos z$

$\cos^2 z + \sin^2 z = 1$ | $\cosh^2 z - \sinh^2 z = 1$ | $\cosh(\mathrm{i}z) = \cos z$

$\mathrm{e}^{\mathrm{i}z} = \cos z + \mathrm{i}\sin z$ | $\mathrm{e}^z = \cosh z + \sinh z$ | $\sinh(\mathrm{i}z) = \mathrm{i}\sin z$

$2\cos z = \mathrm{e}^{\mathrm{i}z} + \mathrm{e}^{-\mathrm{i}z}$ | $2\cosh z = \mathrm{e}^z + \mathrm{e}^{-z}$ | $\cos(\mathrm{i}z) = \cosh z$

$2\mathrm{i}\sin z = \mathrm{e}^{\mathrm{i}z} - \mathrm{e}^{-\mathrm{i}z}$ | $2\sinh z = \mathrm{e}^z - \mathrm{e}^{-z}$ | $\sin(\mathrm{i}z) = \mathrm{i}\sinh z$

Reihen

$$\mathrm{e}^z = \sum_{k=0}^{\infty} \frac{z^k}{k!} \quad \Big| \quad \mathrm{e}^z = \lim_{n\to\infty}\left(1+\frac{z}{n}\right)^n \quad \Big| \quad \ln z = \lim_{h\to 0}\frac{z^h - 1}{h}$$

$\sin z = \sum_{k=0}^{\infty}(-1)^k \frac{z^{2k+1}}{(2k+1)!}$ | $\sinh z = \sum_{k=0}^{\infty} \frac{z^{2k+1}}{(2k+1)!}$

$\cos z = \sum_{k=0}^{\infty}(-1)^k \frac{z^{2k}}{(2k)!}$ | $\cosh z = \sum_{k=0}^{\infty} \frac{z^{2k}}{(2k)!}$

$$\frac{z}{\mathrm{e}^z - 1} = \sum_{k=0}^{\infty} \overline{B}_k \frac{z^k}{k!} \quad \Big| \quad \ln(1-x) = (-1)\sum_{k=1}^{\infty}\frac{x^k}{k} \quad (-1 \le x < 1)$$

$$\frac{z}{1-\mathrm{e}^{-z}} = \sum_{k=0}^{\infty} B_k \frac{z^k}{k!} \quad \Big| \quad (z+1)^a = \sum_{k=0}^{\infty}\binom{a}{k} z^k \quad (a \in \mathbb{C}, |z|<1)$$

$$\frac{1}{1-z} = \sum_{k=0}^{\infty} z^k \quad \Big| \quad \frac{1}{(1-z)^n} = \sum_{k=0}^{\infty}\binom{n+k-1}{k} z^k \quad (|z|<1)$$

$$f[a](z) := \mathrm{e}^{(z-a)D} f(a) = \sum_{k=0}^{\infty}\frac{f^{(k)}(a)}{k!}(z-a)^k$$

Differentialrechnung | $x_{n+1} = x_n - f(x_n)/f'(x_n)$

$$f'(x) := \lim_{h\to 0}\frac{f(x+h)-f(x)}{h} \quad \Big| \quad T(x) = f(x_0) + f'(x_0)(x-x_0), \quad N(x) = f(x_0) - \frac{1}{f'(x_0)}(x-x_0)$$

$(\mathrm{e}^x)' = \mathrm{e}^x$ | $(fg)' = f'g + g'f$

$\ln' x = 1/x$ | $(f/g)' = (f'g - g'f)/g^2$

$(a^x)' = a^x \ln a$ | $(g \circ f)' = (g' \circ f) f'$

$(x^n)' = nx^{n-1}$ | $(f^{-1})' = 1/(f' \circ f^{-1})$

$\sin' x = \cos x$ | $\tan' x = 1 + \tan^2 x = 1/\cos^2 x$

$\cos' x = -\sin x$ | $\cot' x = -1 - \cot^2 x = -1/\sin^2 x$

$\sinh' x = \cosh x$ | $\tanh' x = 1 - \tanh^2 x = 1/\cosh^2 x$

$\cosh' x = \sinh x$ | $\coth' x = 1 - \coth^2 x = -1/\sinh^2 x$

$\arcsin' x = 1/\sqrt{1-x^2}$ | $\arctan' x = 1/(1+x^2)$

$\arccos' x = -1/\sqrt{1-x^2}$ | $\operatorname{arccot}' x = -1/(1+x^2)$

$\operatorname{arsinh}' x = 1/\sqrt{x^2+1}$ | $\operatorname{artanh}' x = 1/(1-x^2)$

$\operatorname{arcosh}' x = 1/\sqrt{x^2-1}$ | $\operatorname{arcoth}' x = 1/(1-x^2)$

Integralrechnung

$$\int_a^b f(x)\,\mathrm{d}x := \lim_{n\to\infty}\sum_{k=1}^n f\big(a + k\tfrac{b-a}{n}\big)\tfrac{b-a}{n} \quad (f \in C[a,b])$$

$$\int_a^b f'(x)\,\mathrm{d}x = [f(x)]_a^b := f(a) - f(b) \quad (f \in C^1[a,b])$$

$$\int_a^b f(g(x))\,g'(x)\,\mathrm{d}x = \int_{g(a)}^{g(b)} f(u)\,\mathrm{d}u \quad \left(\begin{smallmatrix} f \in C(I,\mathbb{R}), \\ g \in C^1([a,b],I) \end{smallmatrix}\right)$$

$$\int_a^b f'(x)g(x)\,\mathrm{d}x = [f(x)g(x)]_a^b - \int_a^b f(x)g'(x)\,\mathrm{d}x \quad (f, g \in C^1)$$

$$t = \tan(\tfrac{x}{2}),\ \sin x = \tfrac{2t}{1+t^2},\ \cos x = \tfrac{1-t^2}{1+t^2},\ \mathrm{d}x = \tfrac{2\mathrm{d}t}{1+t^2}$$

$$L\{f(t)\} := \int_0^{\infty} f(t)\mathrm{e}^{-pt}\mathrm{d}t,\ F\{f(t)\} := \tfrac{1}{\sqrt{2\pi}}\int_{-\infty}^{\infty} f(t)\mathrm{e}^{-\mathrm{i}\omega t}\mathrm{d}t$$

$$\frac{\mathrm{d}}{\mathrm{d}x}\int_{a(x)}^{b(x)} f(x,t)\,\mathrm{d}t = \int_{a(x)}^{b(x)}\frac{\partial}{\partial x} f(x,t)\,\mathrm{d}t + g(x)$$

$$g(x) = f(x, b(x))b'(x) - f(x, a(x))a'(x)$$

Komplexe Zahlen

$z = r\mathrm{e}^{\mathrm{i}\varphi} = a + b\mathrm{i}$ | $|z| = r = \sqrt{a^2+b^2}$

$\overline{z} = r\mathrm{e}^{-\mathrm{i}\varphi} = a - b\mathrm{i}$ | $\arg(z) = \varphi = \operatorname{sgn}(b)\arccos(a/r)$

$\operatorname{Re} z = a = r\cos\varphi$ | $z_1 + z_2 = (a_1 + a_2) + (b_1 + b_2)\mathrm{i}$

$\operatorname{Im} z = b = r\sin\varphi$ | $z_2 - z_2 = (a_1 - a_2) + (b_1 - b_2)\mathrm{i}$

$$z_1 z_2 = r_1 r_2 \mathrm{e}^{\mathrm{i}(\varphi_1+\varphi_2)} = (a_1 a_2 - b_1 b_2) + (a_1 b_2 + a_2 b_1)\mathrm{i}$$

$$\frac{z_1}{z_2} = \frac{r_1}{r_2}\mathrm{e}^{\mathrm{i}(\varphi_1-\varphi_2)} = \frac{a_1 a_2 + b_1 b_2}{a_2^2 + b_2^2} + \frac{a_2 b_1 - a_1 b_2}{a_2^2 + b_2^2}\mathrm{i}$$

$$\frac{1}{z} = \frac{1}{r}\mathrm{e}^{-\mathrm{i}\varphi} = \frac{a}{a^2+b^2} - \frac{b}{a^2+b^2}\mathrm{i}$$

Algebra

$$x^2 + px + q = 0:\ \ x = -\tfrac{p}{2} \pm \tfrac{1}{2}\sqrt{p^2 - 4q}$$

$f(x) = f(2a - x)$ (Achsensymmetrie)

$f(x) = 2b - f(2a - x)$ (Punktsymmetrie)

Lineare Algebra

$\langle Av, w\rangle = \langle v, A^H w\rangle$ | $(AB)^H = B^H A^H$

$\langle v, w\rangle = |v||w|\cos\varphi$ | $(AB)^{-1} = B^{-1}A^{-1}$

$|v \times w| = |v||w|\sin\varphi$ | $\det(AB) = \det(A)\det(B)$

$$\operatorname{proj}[w](v) = \tfrac{\langle v, w\rangle}{\langle w, w\rangle} w, \quad w_k := v_k - \textstyle\sum_{i=1}^{k-1}\operatorname{proj}[w_i](v_k)$$

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

$$\begin{pmatrix} a & b \\ c & d \end{pmatrix}^{-1} = \frac{1}{ad-bc}\begin{pmatrix} d & -b \\ -c & a \end{pmatrix}, \quad R(\varphi) = \begin{pmatrix} \cos\varphi & -\sin\varphi \\ \sin\varphi & \cos\varphi \end{pmatrix}$$

Polarkoordinaten

$x = r\cos\varphi$

$y = r\sin\varphi$

$\varphi \in (-\pi, \pi]$

$\det J = r$

Zylinderkoordinaten

$x = r_{xy}\cos\varphi$

$y = r_{xy}\sin\varphi$

$z = z$

$\det J = r_{xy}$

Kugelkoordinaten

$x = r\sin\theta\,\cos\varphi$

$y = r\sin\theta\,\sin\varphi$

$z = r\cos\theta$

$\varphi \in (-\pi, \pi],\ \theta \in [0, \pi]$

$\det J = r^2\sin\theta$

$\theta = \beta - \pi/2$

$\beta \in [-\pi/2, \pi/2]$

$\cos\theta = \sin\beta$

$\sin\theta = \cos\beta$

Vektoranalysis

$\nabla(|\mathbf{x}|^2) = 2\mathbf{x}$ | $\nabla(fg) = g\nabla f + f\nabla g$

$\nabla|\mathbf{x}| = \mathbf{x}/|\mathbf{x}|$ | $\nabla\langle f, g\rangle = (Df)^T g + (Dg)^T f$

$\nabla(\frac{1}{g}) = -\frac{\nabla g}{g^2}$ | $\nabla(f/g) = (g\nabla f - f\nabla g)/g^2$

$\nabla \times \nabla f = 0$ | $\langle\nabla, f\mathbf{v}\rangle = \langle\nabla f, \mathbf{v}\rangle + f\langle\nabla, \mathbf{v}\rangle$

$\langle\nabla, \nabla \times \mathbf{v}\rangle = 0$ | $\nabla \times (f\mathbf{v}) = f(\nabla \times \mathbf{v}) - \mathbf{v} \times \nabla f$

$$\nabla \times \nabla \times \mathbf{v} = \nabla\langle\nabla, \mathbf{v}\rangle - \Delta\mathbf{v}$$

$$\langle\nabla, v \times w\rangle = \langle\mathbf{w}, \nabla \times \mathbf{v}\rangle - \langle\mathbf{v}, \nabla \times \mathbf{w}\rangle$$

$$\int_\gamma f\,\mathrm{d}s := \int_a^b f(t)\,|\gamma'(t)|\,\mathrm{d}t,\ \int_\gamma\langle\mathbf{F}, \mathrm{d}\mathbf{x}\rangle := \int_a^b\langle\mathbf{F}(\mathbf{x}(t)), \mathbf{x}'(t)\rangle\,\mathrm{d}t$$

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

Extremwerte

$$f(x) = \text{extrem} \Rightarrow f'(x) = 0,\ \ f(p) = \text{extrem} \Rightarrow \mathrm{d}f_p = 0$$

$$f(x,y) = \text{extrem unter } g(x,y) = 0 \Rightarrow \mathrm{d}f = \lambda\mathrm{d}g$$

$$J[\mathbf{x}] := \int_a^b L(t, \mathbf{x}(t), \mathbf{x}'(t))\,\mathrm{d}t = \text{extrem} \Rightarrow \frac{\partial L}{\partial x_k} = \frac{\mathrm{d}}{\mathrm{d}t}\frac{\partial L}{\partial x_k'}$$

Interpolation

Linear: $p(x) = y_1 + \dfrac{y_2 - y_1}{x_2 - x_1}(x - x_1)$

Quadratisch: $p(x) = y_0 + a_1(x - x_0) + a_2(x - x_0)(x - x_1)$

$$a_1 = \frac{y_1 - y_0}{x_1 - x_0}, \quad a_2 = \frac{1}{x_2 - x_1}\left(\frac{y_2 - y_0}{x_2 - x_0} - a_1\right)$$

Regression

$$y = \overline{y} + \frac{s_{xy}}{s_x}(x - \overline{x}),\ \ s_x = \sum_{k=1}^n (x_k - \overline{x})^2,\ \ s_{xy} = \sum_{k=1}^n (x_k - \overline{x})(y_k - \overline{y})$$

Logik

A	B	$A \wedge B$	$A \vee B$	$A \to B$	$A \leftrightarrow B$	$A \oplus B$	$A \uparrow B$
0	0	0	0	1	1	0	1
0	1	0	1	1	0	1	1
1	0	0	1	0	0	1	1
1	1	1	1	1	1	0	0

Disjunktion	**Konjunktion**	**Bezeichnung**
$A \vee A \equiv A$	$A \wedge A \equiv A$	Idempotenzgesetze
$A \vee 0 \equiv A$	$A \wedge 1 \equiv A$	Neutralitätsgesetze
$A \vee 1 \equiv 1$	$A \wedge 0 \equiv 0$	Extremalgesetze
$A \vee \overline{A} \equiv 1$	$A \wedge \overline{A} \equiv 0$	Komplementärgesetze
$A \vee B \equiv B \vee A$	$A \wedge B \equiv B \wedge A$	Kommutativgesetze
$(A \vee B) \vee C \equiv A \vee (B \vee C)$	$(A \wedge B) \wedge C \equiv A \wedge (B \wedge C)$	Assoziativgesetze
$\overline{A \vee B} \equiv \overline{A} \wedge \overline{B}$	$\overline{A \wedge B} \equiv \overline{A} \vee \overline{B}$	De Morgansche Regeln
$A \vee (A \wedge B) \equiv A$	$A \wedge (A \vee B) \equiv A$	Absorptionsgesetze

$(A \to B) \equiv \overline{A} \vee B$ | $(A \leftrightarrow B) \equiv (A \to B) \wedge (B \to A)$

$(A \to B) \equiv (\overline{B} \to \overline{A})$ | $(A \leftrightarrow B) \equiv (\overline{A} \vee B) \wedge (\overline{B} \vee A)$

$A \vee \forall_x P_x \equiv \forall_x (A \vee P_x)$ | $\forall_x (P_x \wedge Q_x) \equiv \forall_x P_x \wedge \forall_x Q_x$

$A \wedge \exists_x P_x \equiv \exists_x (A \wedge P_x)$ | $\exists_x (P_x \vee Q_x) \equiv \exists_x P_x \vee \exists_x Q_x$

$(I \models M) :\Leftrightarrow \forall \varphi \in M\colon I(\varphi)$

$(\models \varphi) :\Leftrightarrow \forall I\colon I(\varphi)$ | $(M \models \varphi) :\Leftrightarrow \forall I\colon ((I \models M) \Rightarrow I(\varphi))$

$\mathrm{erf}(\varphi) :\Leftrightarrow \exists I\colon I(\varphi)$ | $\mathrm{erf}(M) :\Leftrightarrow \exists I\colon (I \models M)$

$\mathrm{erf}(\{\varphi_1, \ldots, \varphi_n\}) \Leftrightarrow \mathrm{erf}(\varphi_1 \wedge \ldots \wedge \varphi_n)$

$\mathrm{erf}(\varphi_1 \vee \ldots \vee \varphi_n) \Leftrightarrow \mathrm{erf}(\varphi_1) \vee \ldots \vee \mathrm{erf}(\varphi_n)$

$(M \vdash \varphi) \Rightarrow (M \models \varphi)$ (Korrektheit)

$(M \models \varphi) \Rightarrow (M \vdash \varphi)$ (Vollständigkeit)

$(M \cup \{\varphi\} \vdash \psi) \Leftrightarrow (M \vdash \varphi \to \psi)$

$(M \cup \{\varphi\} \models \psi) \Leftrightarrow (M \models \varphi \to \psi)$

Mengenlehre

$A \cap B := \{x \mid x \in A \wedge x \in B\}$ | $A \subseteq B :\Leftrightarrow \forall_x (x \in A \Rightarrow x \in B)$

$A \cup B := \{x \mid x \in A \vee x \in B\}$ | $A = B :\Leftrightarrow \forall_x (x \in A \Leftrightarrow x \in B)$

$A \setminus B := \{x \mid x \in A \wedge x \notin B\}$ | $A = B :\Leftrightarrow A \subseteq B \wedge B \subseteq A$

$\bigcap_{i \in I} A_i := \{x \mid \forall i \in I\colon x \in A_i\}$ | $f(M) := \{y \mid \exists x \in M\colon y = f(x)\}$

$\bigcup_{i \in I} A_i := \{x \mid \exists i \in I\colon x \in A_i\}$ | $f^{-1}(N) := \{x \mid f(x) \in N\}$

$A \times B := \{t \mid \exists x \in A\colon \exists y \in B\colon t = (x, y)\}$

$A \subseteq B \Leftrightarrow A \cup B = B \Leftrightarrow A \cap B = A$

$f(M \cup N) = f(M) \cup f(N)$ | $f^{-1}(M \cup N) = f^{-1}(M) \cup f^{-1}(N)$

$f(M \cap N) \subseteq f(M) \cap f(N)$ | $f^{-1}(M \cap N) = f^{-1}(M) \cap f^{-1}(N)$

$M \subseteq N \Rightarrow f(M) \subseteq f(N)$ | $M \subseteq N \Rightarrow f^{-1}(M) \subseteq f^{-1}(N)$

$(g \circ f)(M) = g(f(M))$ | $(g \circ f)^{-1}(M) = f^{-1}(g^{-1}(M))$

Kombinatorik

$$\sum_{k=m}^{n-1} q^k = \frac{q^m - q^n}{q-1}, \quad \sum_{k=m}^{n-1} k^p q^k = \left(q \frac{\mathrm{d}}{\mathrm{d}q}\right)^p \frac{q^m - q^n}{q-1}$$

$\sum_{k=1}^{n} k = (n/2)(n+1)$ | $\sum_{k=m}^{n-1} (\Delta a)_k = a_n - a_m$

$\sum_{k=1}^{n} k^2 = (n/6)(n+1)(2n+1)$ | $(\Delta a)_k := a_{k+1} - a_k$

$\sum_{k=1}^{n} k^3 = (n/2)^2(n+1)^2$ | $n! = n \cdot (n-1)!$

$$(a+b)^n = \sum_{k=0}^{n} \binom{n}{k} a^{n-k} b^k, \quad \binom{n}{k} := \frac{1}{k!} n^{\underline{k}} = \frac{n!}{k!(n-k)!}$$

$$n! = \Gamma(n+1), \quad \Gamma(z+1) = z\Gamma(z), \quad \Gamma(z)\Gamma(1-z) = \frac{\pi}{\sin(\pi z)}$$

$$\tbinom{n+1}{k+1} = \tbinom{n}{k} + \tbinom{n+1}{k}, \quad \tbinom{n}{k} = \tbinom{n}{n-k}, \quad \tbinom{n}{0} = \tbinom{n}{n} = 1$$

$$n! \approx \sqrt{2\pi n}\, n^n \exp\left(\tfrac{1}{12n} - n\right) \approx \sqrt{2\pi n}\,(n/e)^n$$

Mechanik

$$\begin{array}{l|l} \mathbf{v} = \mathbf{x}'(t) & \omega = \varphi'(t) \\ \mathbf{a} = \mathbf{v}'(t) & \alpha = \omega'(t) \\ \mathbf{F} = \mathbf{p}'(t) & \mathbf{M} = \mathbf{L}'(t) \\ \mathbf{p} = m\mathbf{v} & L = J\omega \\ \mathbf{F} = m\mathbf{a} & M = J\alpha \\ P = \langle \mathbf{F}, \mathbf{v} \rangle & P = \langle \mathbf{M}, \boldsymbol{\omega} \rangle \\ E_{\text{kin}} = \frac{1}{2} m |\mathbf{v}|^2 & E_{\text{rot}} = \frac{1}{2} J\omega^2 \end{array}$$

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

Gleichstrom

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

Wechselstrom

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

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

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

Allgemeine Gleichungen

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

Elektrostatisches Feld

$$\begin{array}{l|l} F = \dfrac{1}{4\pi\varepsilon} \dfrac{Q_1 Q_2}{r^2} & \mathbf{F}_1 = \dfrac{1}{4\pi\varepsilon} Q_1 Q_2 \dfrac{\mathbf{x}_1 - \mathbf{x}_2}{|\mathbf{x}_1 - \mathbf{x}_2|^3} \end{array}$$

$$\begin{array}{l|l|l} \mathbf{F} = q\mathbf{E} & Q = CU & U = \varphi(B) - \varphi(A) \\ \mathbf{D} = \varepsilon\mathbf{E} & \varepsilon = \varepsilon_0 \varepsilon_r & W = QU \end{array}$$

$$\mathbf{E} = -\nabla\varphi$$

$$\varepsilon_0 E^2 = 2w_e$$

Plattenkondensator

$$U = Ed \;\big|\; C = \varepsilon A/d$$

Homogenes Feld in der Spule

$$Hl = NI \;\big|\; Bl = \mu NI \;\big|\; \Theta = NI$$

Magnetostatisches Feld

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

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

$$B^2 = 2\mu_0 w_m$$

Elektrodynamik

$$\mathbf{E} = -\nabla\varphi$$

$$\varepsilon\Delta\varphi = -\rho(x)$$

$$\varepsilon_0 E^2 = 2w_e$$

$$B^2 = 2\mu_0 w_m$$

Maxwell-Gleichungen

$$\begin{array}{l|l} \langle \nabla, \mathbf{D} \rangle = \rho_f(x) & \langle \nabla, \varepsilon_0 \mathbf{E} \rangle = \rho(x) \\ \langle \nabla, \mathbf{B} \rangle = 0 & \langle \nabla, \mathbf{B} \rangle = 0 \\ \nabla \times \mathbf{E} = -\partial_t \mathbf{B} & \nabla \times \mathbf{E} = -\partial_t \mathbf{B} \\ \nabla \times \mathbf{H} = \mathbf{J}_f + \partial_t \mathbf{D} & \nabla \times \mathbf{B} = \mu_0 (\mathbf{J} + \varepsilon_0 \partial_t \mathbf{E}) \end{array}$$

Spezielle Relativitätstheorie

$$\gamma = \frac{1}{\sqrt{1 - \beta^2}}, \quad \beta = v/c$$

$$\gamma = \cosh\varphi, \quad \beta\gamma = \sinh\varphi, \quad \beta = \tanh\varphi$$

$$ct' = \gamma(ct - \beta x), \quad x' = \gamma(x - vt), \quad (y, z)' = (y, z)$$

$$\begin{array}{l|l} t = \gamma\tau & E_{\text{kin}} = E - E_0 \\ p = \gamma m v & E_{\text{kin}} = \gamma mc^2 - mc^2 \\ E = \gamma mc^2 & E^2 = (pc)^2 + (mc^2)^2 \end{array}$$

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

$$g = \operatorname{diag}(1, -1, -1, -1)$$

$$(\partial_\mu) = (\partial_{ct}, \partial_x, \partial_y, \partial_z)$$

$$(\partial^\mu) = (\partial_{ct}, -\partial_x, -\partial_y, -\partial_z)$$

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

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

$$pV = nRT$$

$$\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2}$$

$$Q = mc\Delta T$$

Konstanten

$$\varepsilon_0 = 8.8542 \times 10^{-12}\,\mathrm{C/(V\,m)}$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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