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

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

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

$\frac{z}{\mathrm{e}^z - 1} = \sum_{k=0}^{\infty} \overline{B}_k \frac{z^k}{k!}$	$\ln(1-x) = (-1)\sum_{k=1}^{\infty}\frac{x^k}{k} \quad (-1 \le x < 1)$
$\frac{z}{1-\mathrm{e}^{-z}} = \sum_{k=0}^{\infty} B_k \frac{z^k}{k!}$	$(z+1)^a = \sum_{k=0}^{\infty}\binom{a}{k} z^k \quad (a \in \mathbb{C}, \lvert z\rvert < 1)$
$\frac{1}{1-z} = \sum_{k=0}^{\infty} z^k$	$\frac{1}{(1-z)^n} = \sum_{k=0}^{\infty}\binom{n+k-1}{k} z^k \quad (\lvert z\rvert<1)$

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

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

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

$(\mathrm{e}^x)' = \mathrm{e}^x$	$(fg)' = f'g + g'f$
$\ln' x = 1/x$	$(f/g)' = (f'g - g'f)/g^2$
$(a^x)' = a^x \ln a$	$(g \circ f)' = (g' \circ f)f'$
$(x^n)' = nx^{n-1}$	$(f^{-1})' = 1/(f' \circ f^{-1})$

$\sin' x = \cos x$	$\tan' x = 1 + \tan^2 x = 1/\cos^2 x$
$\cos' x = -\sin x$	$\cot' x = -1 - \cot^2 x = -1/\sin^2 x$
$\sinh' x = \cosh x$	$\tanh' x = 1 - \tanh^2 x = 1/\cosh^2 x$
$\cosh' x = \sinh x$	$\coth' x = 1 - \coth^2 x = -1/\sinh^2 x$

$\arcsin' x = 1/\sqrt{1-x^2}$	$\arctan' x = 1/(1+x^2)$
$\arccos' x = -1/\sqrt{1-x^2}$	$\operatorname{arccot}' x = -1/(1+x^2)$
$\operatorname{arsinh}' x = 1/\sqrt{x^2+1}$	$\operatorname{artanh}' x = 1/(1-x^2)$
$\operatorname{arcosh}' x = 1/\sqrt{x^2-1}$	$\operatorname{arcoth}' x = 1/(1-x^2)$

Integralrechnung

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

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

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

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

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

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

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

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

Komplexe Zahlen

$z = r\mathrm{e}^{\mathrm{i}\varphi} = a + b\mathrm{i}$	$\lvert z\rvert = r = \sqrt{a^2+b^2}$
$\overline{z} = r\mathrm{e}^{-\mathrm{i}\varphi} = a - b\mathrm{i}$	$\arg(z) = \varphi = \operatorname{sgn}(b)\arccos(a/r)$
$\operatorname{Re} z = a = r\cos\varphi$	$z_1 + z_2 = (a_1 + a_2) + (b_1 + b_2)\mathrm{i}$
$\operatorname{Im} z = b = r\sin\varphi$	$z_2 - z_2 = (a_1 - a_2) + (b_1 - b_2)\mathrm{i}$

$$z_1 z_2 = r_1 r_2 \mathrm{e}^{\mathrm{i}(\varphi_1+\varphi_2)} = (a_1a_2 - b_1b_2) + (a_1b_2 + a_2b_1)\mathrm{i}$$

$$\frac{z_1}{z_2} = \frac{r_1}{r_2}\mathrm{e}^{\mathrm{i}(\varphi_1-\varphi_2)} = \frac{a_1a_2 + b_1b_2}{a_2^2 + b_2^2} + \frac{a_2b_1 - a_1b_2}{a_2^2+b_2^2}\mathrm{i}$$

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

Algebra

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

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

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

Lineare Algebra | $\det(\lambda A) = \lambda^n \det(A),\ \det(A^{-1}) = \frac{1}{\det A}$

$\langle Av, w\rangle = \langle v, A^H w\rangle$	$(AB)^H = B^H A^H$
$\langle v, w\rangle = \lvert v\rvert\lvert w\rvert\cos\varphi$	$(AB)^{-1} = B^{-1}A^{-1}$
$\lvert v \times w\rvert = \lvert v\rvert\lvert w\rvert\sin\varphi$	$\det(AB) = \det(A)\det(B)$

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

$$\begin{pmatrix}a_1\\a_2\\a_3\end{pmatrix} \times \begin{pmatrix}b_1\\b_2\\b_3\end{pmatrix} = \begin{pmatrix}a_2b_3 - a_3b_2\\a_3b_1 - a_1b_3\\a_1b_2 - a_2b_1\end{pmatrix}$$

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

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

$\nabla(\lvert\mathbf{x}\rvert^2) = 2\mathbf{x}$	$\nabla(fg) = g\nabla f + f\nabla g$
$\nabla\lvert\mathbf{x}\rvert = \mathbf{x}/\lvert\mathbf{x}\rvert$	$\nabla\langle f, g\rangle = (Df)^T g + (Dg)^T f$
$\nabla(\frac{1}{g}) = -\frac{\nabla g}{g^2}$	$\nabla(f/g) = (g\nabla f - f\nabla g)/g^2$
$\nabla \times \nabla f = 0$	$\langle\nabla, f\mathbf{v}\rangle = \langle\nabla f, \mathbf{v}\rangle + f\langle\nabla, \mathbf{v}\rangle$
$\langle\nabla, \nabla\times\mathbf{v}\rangle = 0$	$\nabla\times(f\mathbf{v}) = f(\nabla\times\mathbf{v}) - \mathbf{v}\times\nabla f$

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

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

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

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

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

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

Logik

A	B	$A \land B$	$A \lor B$	$A \to B$	$A \leftrightarrow B$	$A \oplus B$	$A \uparrow B$
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
$A \lor A \equiv A$	$A \land A \equiv A$	Idempotenzgesetze
$A \lor 0 \equiv A$	$A \land 1 \equiv A$	Neutralitätsgesetze
$A \lor 1 \equiv 1$	$A \land 0 \equiv 0$	Extremalgesetze
$A \lor \overline{A} \equiv 1$	$A \land \overline{A} \equiv 0$	Komplementärgesetze
$A \lor B \equiv B \lor A$	$A \land B \equiv B \land A$	Kommutativgesetze
$(A \lor B) \lor C \equiv A \lor (B \lor C)$	$(A \land B) \land C \equiv A \land (B \land C)$	Assoziativgesetze
$\overline{A \lor B} \equiv \overline{A} \land \overline{B}$	$\overline{A \land B} \equiv \overline{A} \lor \overline{B}$	De Morgansche Regeln
$A \lor (A \land B) \equiv A$	$A \land (A \lor B) \equiv A$	Absorptionsgesetze

$(A \to B) \equiv \overline{A} \lor B$ | $(A \leftrightarrow B) \equiv (A \to B) \land (B \to A)$

$(A \to B) \equiv (\overline{B} \to \overline{A})$ | $(A \leftrightarrow B) \equiv (\overline{A} \lor B) \land (\overline{B} \lor A)$

$A \lor \forall_x P_x \equiv \forall_x (A \lor P_x)$ | $\forall_x (P_x \land Q_x) \equiv \forall_x P_x \land \forall_x Q_x$

$A \land \exists_x P_x \equiv \exists_x (A \land P_x)$ | $\exists_x (P_x \lor Q_x) \equiv \exists_x P_x \lor \exists_x Q_x$

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

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

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

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

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

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

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

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

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

$(M \models \varphi_1) \land (M \models \varphi_2) \land (\{\varphi_1, \varphi_2\} \models \psi) \Rightarrow (M \models \psi)$

Mengenlehre

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

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

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

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

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

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

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

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

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

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

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

Kombinatorik

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

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

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

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

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

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

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

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

Twelvefold way. Fächer: $n := |N|$, Karten: $k := |K|$

	$f\colon K \to N$	$f \in \mathrm{Inj}(K, N)$	$f \in \mathrm{Sur}(K, N)$
f	n^k	$n^{\underline{k}}$	$n!{k \brace n}$
$f \circ S_k$	$\binom{n+k-1}{k}$	$\binom{n}{k}$	$\binom{k-1}{k-n}$
$S_n \circ f$	$\sum_{i=0}^n {k \brace i}$	$[k \leq n]$	${k \brace n}$
$S_n \circ f \circ S_k$	$p_n(n+k)$	$[k \leq n]$	$p_n(k)$

S_k: Karten nicht unterscheidbar | Inj: max. 1 Karte pro Fach

S_n: Fächer nicht unterscheidbar | Sur: mind. 1 Karte pro Fach

${n \brace k} = k{n-1 \brace k} + {n-1 \brace k-1}$ | ${n \brace 0} = {n \brack 0} = [n=0]$

${n \brack k} = (n-1){n-1 \brack k} + {n-1 \brack k-1}$ | ${n \brace 1} = [n>0]$

$x^n = \sum_{k=0}^n {n \brace k} x^{\underline{k}}$ | ${n \brace 2} = (2^{n-1} - 1)[n>0]$

Wahrscheinlichkeitsrechnung

$P(A \cup B) = P(A) + P(B) - P(A \cap B)$

$P(A \cap B) = P(A)P(B \mid A)$

A unabhängig zu $B :\Leftrightarrow P(A \cap B) = P(A)P(B)$

$P(A) = \sum_{k=1}^n P(A \mid B_k)P(B_k)$ für Zerlegung (B_k) von Ω

$P(A) = \int_{-\infty}^{\infty} P(A \mid X = x)\,\mathrm{d}F_X(x)$

$E(X) = \sum_{\omega \in \Omega} X(\omega)P(\{\omega\}) = \sum_{x \in \Omega'} xP(X = x)$

$E(X) = \int_{-\infty}^{\infty} xf(x)\,\mathrm{d}x = \int_0^{\infty} (1 - F(x))\,\mathrm{d}x - \int_{-\infty}^0 F(x)\,\mathrm{d}x$

$E(g(X)) = \int_{-\infty}^{\infty} g(x)f(x)\,\mathrm{d}x$ | $P(A) = E(1_A)$

$E(X \mid A) = E(1_A X)/P(A)$ | $P(A \mid B) = E(1_A \mid B)$

Normalverteilung

$\Phi(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^x \mathrm{e}^{-t^2/2}\,\mathrm{d}t = \frac{1}{2} + \frac{1}{2}\mathrm{erf}(\frac{x}{\sqrt{2}})$

$F(x) = \Phi(\frac{x - \mu}{\sigma})$

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

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

$H = I/(2\pi r)$ (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

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

$pV = nRT$

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

$Q = mc\Delta T$

Konstanten

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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