

## Winkelfunktionen

$$\begin{array}{l|l} \sin(x+y) = \sin x \cos y + \cos x \sin y & \sin(z \pm \pi) = -\sin z \\ \sin(x-y) = \sin x \cos y - \cos x \sin y & \cos(z \pm \pi) = -\cos z \\ \cos(x+y) = \cos x \cos y - \sin x \sin y & \sin(\pi/2 - x) = \cos x \\ \cos(x-y) = \cos x \cos y + \sin x \sin y & \cos(\pi/2 - x) = \sin x \\ \sin(nx) = 2 \cos x \sin((n-1)x) - \sin((n-2)x) & \sin(-z) = -\sin z \\ \cos(nx) = 2 \cos x \cos((n-1)x) - \cos((n-2)x) & \cos(-z) = \cos z \\ \cos^2 z + \sin^2 z = 1 & \cosh^2 z - \sinh^2 z = 1 \\ e^{iz} = \cos z + i \sin z & e^z = \cosh z + \sinh z \\ 2 \cos z = e^{iz} + e^{-iz} & 2 \cosh z = e^z + e^{-z} \\ 2i \sin z = e^{iz} - e^{-iz} & 2 \sinh z = e^z - e^{-z} \\ & \cosh(iz) = \cos z \\ & \sinh(iz) = i \sin z \\ & \cos(iz) = \cosh z \\ & \sin(iz) = i \sinh z \end{array}$$

## Reihen

$$\begin{array}{l} e^z = \sum_{k=0}^{\infty} \frac{z^k}{k!} \quad \left| \quad e^z = \lim_{n \rightarrow \infty} \left(1 + \frac{z}{n}\right)^n \quad \left| \quad \ln z = \lim_{h \rightarrow 0} \frac{z^h - 1}{h} \right. \\ \sin z = \sum_{k=0}^{\infty} (-1)^k \frac{z^{2k+1}}{(2k+1)!} \quad \left| \quad \sinh z = \sum_{k=0}^{\infty} \frac{z^{2k+1}}{(2k+1)!} \right. \\ \cos z = \sum_{k=0}^{\infty} (-1)^k \frac{z^{2k}}{(2k)!} \quad \left| \quad \cosh z = \sum_{k=0}^{\infty} \frac{z^{2k}}{(2k)!} \right. \\ \frac{z}{e^z - 1} = \sum_{k=0}^{\infty} \bar{B}_k \frac{z^k}{k!} \quad \left| \quad \ln(1-x) = (-1) \sum_{k=1}^{\infty} \frac{x^k}{k} \quad (-1 \leq x < 1) \right. \\ \frac{z}{1 - e^{-z}} = \sum_{k=0}^{\infty} B_k \frac{z^k}{k!} \quad \left| \quad (z+1)^a = \sum_{k=0}^{\infty} \binom{a}{k} z^k \quad (a \in \mathbb{C}, |z| < 1) \right. \\ \frac{1}{1-z} = \sum_{k=0}^{\infty} z^k \quad \left| \quad \frac{1}{(1-z)^n} = \sum_{k=0}^{\infty} \binom{n+k-1}{k} z^k \quad (|z| < 1) \right. \\ f[a](z) := e^{(z-a)D} f(a) = \sum_{k=0}^{\infty} \frac{f^{(k)}(a)}{k!} (z-a)^k \end{array}$$

## Differentialrechnung

$$\begin{array}{l|l} f'(x) := \lim_{h \rightarrow 0} \frac{f(x+h)-f(x)}{h} & T(x) = f(x_0) + f'(x_0)(x-x_0) \\ & N(x) = f(x_0) - \frac{1}{f'(x_0)}(x-x_0) \\ (e^x)' = e^x & (fg)' = f'g + g'f \\ \ln' x = 1/x & (f/g)' = (f'g - g'f)/g^2 \\ (a^x)' = a^x \ln a & (g \circ f)' = (g' \circ f)f' \\ (x^n)' = nx^{n-1} & (f^{-1})' = 1/(f' \circ f^{-1}) \\ \sin' x = \cos x & \tan' x = 1 + \tan^2 x = 1/\cos^2 x \\ \cos' x = -\sin x & \cot' x = -1 - \cot^2 x = -1/\sin^2 x \\ \sinh' x = \cosh x & \tanh' x = 1 - \tanh^2 x = 1/\cosh^2 x \\ \cosh' x = \sinh x & \coth' x = 1 - \coth^2 x = -1/\sinh^2 x \\ \arcsin' x = 1/\sqrt{1-x^2} & \arctan' x = 1/(1+x^2) \\ \arccos' x = -1/\sqrt{1-x^2} & \operatorname{arccot}' x = -1/(1+x^2) \\ \operatorname{arsinh}' x = 1/\sqrt{x^2+1} & \operatorname{artanh}' x = 1/(1-x^2) \\ \operatorname{arcosh}' x = 1/\sqrt{x^2-1} & \operatorname{arcoth}' x = 1/(1-x^2) \end{array}$$

## Integralrechnung

$$\begin{array}{l} \int_a^b f(x) dx := \lim_{n \rightarrow \infty} \sum_{k=1}^n f(a + k \frac{b-a}{n}) \frac{b-a}{n} \quad (f \in C[a, b]) \\ \int_a^b f'(x) dx = [f(x)]_a^b := f(b) - f(a) \quad (f \in C^1[a, b]) \\ \int_a^b f(g(x)) g'(x) dx = \int_{g(a)}^{g(b)} f(u) du \quad \left( \begin{array}{l} f \in C(I, \mathbb{R}), \\ g \in C^1([a, b], I) \end{array} \right) \\ \int_a^b f'(x) g(x) dx = [f(x) g(x)]_a^b - \int_a^b f(x) g'(x) dx \quad (f, g \in C^1) \\ t = \tan(\frac{x}{2}), \quad \sin x = \frac{2t}{1+t^2}, \quad \cos x = \frac{1-t^2}{1+t^2}, \quad dx = \frac{2dt}{1+t^2} \\ L\{f(t)\} := \int_0^{\infty} f(t) e^{-pt} dt, \quad F\{f(t)\} := \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} f(t) e^{-i\omega t} dt \\ \frac{d}{dx} \int_{a(x)}^{b(x)} f(x, t) dt = \int_{a(x)}^{b(x)} \frac{\partial}{\partial x} f(x, t) dt + g(x) \\ g(x) = f(x, b(x)) b'(x) - f(x, a(x)) a'(x) \end{array}$$

## Komplexe Zahlen

$$\begin{array}{l|l} z = r e^{i\varphi} = a + bi & |z| = r = \sqrt{a^2 + b^2} \\ \bar{z} = r e^{-i\varphi} = a - bi & \arg(z) = \varphi = \operatorname{sgn}(b) \arccos(a/r) \\ \operatorname{Re} z = a = r \cos \varphi & z_1 + z_2 = (a_1 + a_2) + (b_1 + b_2)i \\ \operatorname{Im} z = b = r \sin \varphi & z_1 - z_2 = (a_1 - a_2) + (b_1 - b_2)i \\ z_1 z_2 = r_1 r_2 e^{i(\varphi_1 + \varphi_2)} = (a_1 a_2 - b_1 b_2) + (a_1 b_2 + a_2 b_1)i \\ \frac{z_1}{z_2} = \frac{r_1}{r_2} e^{i(\varphi_1 - \varphi_2)} = \frac{a_1 a_2 + b_1 b_2}{a_2^2 + b_2^2} + \frac{a_2 b_1 - a_1 b_2}{a_2^2 + b_2^2} i \\ \frac{1}{z} = \frac{1}{r} e^{-i\varphi} = \frac{a}{a^2 + b^2} - \frac{b}{a^2 + b^2} i \end{array}$$

## Algebra

$$\begin{array}{l} x^2 + px + q = 0: \quad x = -\frac{p}{2} \pm \frac{1}{2} \sqrt{p^2 - 4q} \\ f(x) = f(2a - x) \quad (\text{Achsensymmetrie}) \\ f(x) = 2b - f(2a - x) \quad (\text{Punktsymmetrie}) \end{array}$$

## Lineare Algebra

$$\begin{array}{l|l} \langle Av, w \rangle = \langle v, A^H w \rangle & (AB)^H = B^H A^H \\ \langle v, w \rangle = |v||w| \cos \varphi & (AB)^{-1} = B^{-1} A^{-1} \\ |v \times w| = |v||w| \sin \varphi & \det(AB) = \det(A) \det(B) \\ \operatorname{proj}[w](v) = \frac{\langle v, w \rangle}{\langle w, w \rangle} w, \quad w_k := v_k - \sum_{i=1}^{k-1} \operatorname{proj}[w_i](v_k) \\ \begin{pmatrix} a_1 \\ a_2 \\ a_3 \end{pmatrix} \times \begin{pmatrix} b_1 \\ b_2 \\ b_3 \end{pmatrix} = \begin{pmatrix} a_2 b_3 - a_3 b_2 \\ a_3 b_1 - a_1 b_3 \\ a_1 b_2 - a_2 b_1 \end{pmatrix} \\ \begin{pmatrix} a & b \\ c & d \end{pmatrix}^{-1} = \frac{1}{ad-bc} \begin{pmatrix} d & -b \\ -c & a \end{pmatrix}, \quad R(\varphi) = \begin{pmatrix} \cos \varphi & -\sin \varphi \\ \sin \varphi & \cos \varphi \end{pmatrix} \end{array}$$

## Polarkoordinaten

$$\begin{array}{l} x = r \cos \varphi \\ y = r \sin \varphi \\ \varphi \in (-\pi, \pi] \\ \det J = r \end{array}$$

## Zylinderkoordinaten

$$\begin{array}{l} x = r_{xy} \cos \varphi \\ y = r_{xy} \sin \varphi \\ z = z \\ \det J = r_{xy} \end{array}$$

## Kugelkoordinaten

$$\begin{array}{l} x = r \sin \theta \cos \varphi \\ y = r \sin \theta \sin \varphi \\ z = r \cos \theta \\ \varphi \in (-\pi, \pi], \quad \theta \in [0, \pi] \\ \det J = r^2 \sin \theta \\ \theta = \beta - \pi/2 \\ \beta \in [-\pi/2, \pi/2] \\ \cos \theta = \sin \beta \\ \sin \theta = \cos \beta \end{array}$$

## Vektoranalysis

$$\begin{array}{l|l} \nabla(|x|^2) = 2x & \nabla(fg) = g \nabla f + f \nabla g \\ \nabla|x| = x/|x| & \nabla \langle f, g \rangle = (Df)^T g + (Dg)^T f \\ \nabla(\frac{1}{g}) = -\frac{\nabla g}{g^2} & \nabla(f/g) = (g \nabla f - f \nabla g)/g^2 \\ \nabla \times \nabla f = 0 & \langle \nabla, f \mathbf{v} \rangle = \langle \nabla f, \mathbf{v} \rangle + f \langle \nabla, \mathbf{v} \rangle \\ \langle \nabla, \nabla \times \mathbf{v} \rangle = 0 & \nabla \times (f \mathbf{v}) = f(\nabla \times \mathbf{v}) - \mathbf{v} \times \nabla f \\ \nabla \times \nabla \times \mathbf{v} = \nabla \langle \nabla, \mathbf{v} \rangle - \Delta \mathbf{v} \\ \langle \nabla, \mathbf{v} \times \mathbf{w} \rangle = \langle \mathbf{w}, \nabla \times \mathbf{v} \rangle - \langle \mathbf{v}, \nabla \times \mathbf{w} \rangle \\ \int_Y f ds := \int_a^b f(t) |\gamma'(t)| dt, \quad \int_Y \langle F, dx \rangle := \int_a^b \langle F(\mathbf{x}(t)), \mathbf{x}'(t) \rangle dt \\ \int_{\varphi(U)} f(\mathbf{x}) d\mathbf{x} = \int_U f(\varphi(\mathbf{u})) |\det D\varphi(\mathbf{u})| d\mathbf{u} \end{array}$$

## Extremwerte

$$\begin{array}{l} f(x) = \text{extrem} \Rightarrow f'(x) = 0, \quad f(p) = \text{extrem} \Rightarrow df_p = 0 \\ f(x, y) = \text{extrem unter } g(x, y) = 0 \Rightarrow df = \lambda dg \\ J[\mathbf{x}] := \int_a^b L(t, \mathbf{x}(t), \mathbf{x}'(t)) dt = \text{extrem} \Rightarrow \frac{\partial L}{\partial x_k} = \frac{d}{dt} \frac{\partial L}{\partial x'_k} \end{array}$$

## Interpolation

$$\begin{array}{l} \text{Linear: } p(x) = y_1 + \frac{y_2 - y_1}{x_2 - x_1} (x - x_1) \\ \text{Quadratisch: } p(x) = y_0 + a_1(x - x_0) + a_2(x - x_0)(x - x_1) \\ a_1 = \frac{y_1 - y_0}{x_1 - x_0}, \quad a_2 = \frac{1}{x_2 - x_1} \left( \frac{y_2 - y_0}{x_2 - x_0} - a_1 \right) \end{array}$$

## Regression

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

Logik

A	B	$A \wedge B$	$A \vee B$	$A \rightarrow B$	$A \leftrightarrow B$	$A \oplus B$	$A \uparrow B$
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
$A \vee \bar{A} \equiv 1$	$A \wedge \bar{A} \equiv 0$	Komplementärsgesetze

$A \vee B \equiv B \vee A$	$A \wedge B \equiv B \wedge A$	Kommutativgesetz
$(A \vee B) \vee C \equiv A \vee (B \vee C)$	$(A \wedge B) \wedge C \equiv A \wedge (B \wedge C)$	Assoziativgesetz
$\overline{A \vee B} \equiv \bar{A} \wedge \bar{B}$	$\overline{A \wedge B} \equiv \bar{A} \vee \bar{B}$	De Morgansche Regeln
$A \vee (A \wedge B) \equiv A$	$A \wedge (A \vee B) \equiv A$	Absorptionsgesetze

$(A \rightarrow B) \equiv \bar{A} \vee B$	$(A \leftrightarrow B) \equiv (A \rightarrow B) \wedge (B \rightarrow A)$
$(A \rightarrow B) \equiv (\bar{B} \rightarrow \bar{A})$	$(A \leftrightarrow B) \equiv (\bar{A} \vee B) \wedge (\bar{B} \vee A)$
$A \vee \forall x P_x \equiv \forall x (A \vee P_x)$	$\forall x (P_x \wedge Q_x) \equiv \forall x P_x \wedge \forall x Q_x$
$A \wedge \exists x P_x \equiv \exists x (A \wedge P_x)$	$\exists x (P_x \vee Q_x) \equiv \exists x P_x \vee \exists x Q_x$
$(I \models M) :\Leftrightarrow \forall \varphi \in M: I(\varphi)$	
$(\models \varphi) :\Leftrightarrow \forall I: I(\varphi)$	$(M \models \varphi) :\Leftrightarrow \forall I: ((I \models M) \Rightarrow I(\varphi))$
$\text{erf}(\varphi) :\Leftrightarrow \exists I: I(\varphi)$	$\text{erf}(M) :\Leftrightarrow \exists I: (I \models M)$
$\text{erf}(\{\varphi_1, \dots, \varphi_n\}) \Leftrightarrow \text{erf}(\varphi_1 \wedge \dots \wedge \varphi_n)$	
$\text{erf}(\varphi_1 \vee \dots \vee \varphi_n) \Leftrightarrow \text{erf}(\varphi_1) \vee \dots \vee \text{erf}(\varphi_n)$	
$(M \vdash \varphi) \Rightarrow (M \models \varphi)$	(Korrektheit)
$(M \models \varphi) \Rightarrow (M \vdash \varphi)$	(Vollständigkeit)
$(M \cup \{\varphi\} \vdash \psi) \Leftrightarrow (M \vdash \varphi \rightarrow \psi)$	
$(M \cup \{\varphi\} \models \psi) \Leftrightarrow (M \models \varphi \rightarrow \psi)$	

Mengenlehre

$A \cap B := \{x \mid x \in A \wedge x \in B\}$	$A \subseteq B :\Leftrightarrow \forall x (x \in A \Rightarrow x \in B)$
$A \cup B := \{x \mid x \in A \vee x \in B\}$	$A = B :\Leftrightarrow \forall x (x \in A \Leftrightarrow x \in B)$
$A \setminus B := \{x \mid x \in A \wedge x \notin B\}$	$A = B :\Leftrightarrow A \subseteq B \wedge B \subseteq A$
$\bigcap_{i \in I} A_i := \{x \mid \forall i \in I: x \in A_i\}$	$f(M) := \{y \mid \exists x \in M: y = f(x)\}$
$\bigcup_{i \in I} A_i := \{x \mid \exists i \in I: x \in A_i\}$	$f^{-1}(N) := \{x \mid f(x) \in N\}$
$A \times B := \{t \mid \exists x \in A: \exists y \in B: t = (x, y)\}$	
$A \subseteq B \Leftrightarrow A \cup B = B \Leftrightarrow A \cap B = A$	
$f(M \cup N) = f(M) \cup f(N)$	$f^{-1}(M \cup N) = f^{-1}(M) \cup f^{-1}(N)$
$f(M \cap N) \subseteq f(M) \cap f(N)$	$f^{-1}(M \cap N) = f^{-1}(M) \cap f^{-1}(N)$
$M \subseteq N \Rightarrow f(M) \subseteq f(N)$	$M \subseteq N \Rightarrow f^{-1}(M) \subseteq f^{-1}(N)$
$(g \circ f)(M) = g(f(M))$	$(g \circ f)^{-1}(M) = f^{-1}(g^{-1}(M))$

Kombinatorik

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

$\sum_{k=1}^n k = (n/2)(n+1) \quad \left| \quad \sum_{k=m}^{n-1} (\Delta a)_k = a_n - a_m \right.$   
 $\sum_{k=1}^n k^2 = (n/6)(n+1)(2n+1) \quad \left| \quad (\Delta a)_k := a_{k+1} - a_k \right.$   
 $\sum_{k=1}^n k^3 = (n/2)^2(n+1)^2 \quad \left| \quad n! = n \cdot (n-1)!\right.$

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

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

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

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

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

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

$S_k$ : Karten nicht unterscheidbar | Inj: max. 1 Karte pro Fach  
 $S_n$ : Fächer nicht unterscheidbar | Sur: mind. 1 Karte pro Fach

$\binom{n}{k} = k \binom{n-1}{k} + \binom{n-1}{k-1} \quad \left| \quad \begin{matrix} \begin{bmatrix} n \\ 0 \end{bmatrix} = \begin{bmatrix} n \\ 0 \end{bmatrix} = [n=0] \\ \begin{bmatrix} n \\ 1 \end{bmatrix} = (n-1) \begin{bmatrix} n-1 \\ k \end{bmatrix} + \begin{bmatrix} n-1 \\ k-1 \end{bmatrix} \\ \begin{matrix} \begin{bmatrix} n \\ 1 \end{bmatrix} = [n>0] \\ \begin{bmatrix} n \\ 2 \end{bmatrix} = (2^{n-1} - 1)[n>0] \end{matrix} \end{matrix} \right.$

Wahrscheinlichkeitsrechnung

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

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

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

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

$P(A) = \int_{-\infty}^{\infty} P(A | X = x) dF_X(x)$

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

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

$E(g(X)) = \int_{-\infty}^{\infty} g(x)f(x) dx$

**Mechanik**

$$\begin{array}{l|l}
\mathbf{v} = \mathbf{x}'(t) & \omega = \varphi'(t) \\
\mathbf{a} = \mathbf{v}'(t) & \alpha = \omega'(t) \\
\mathbf{F} = \mathbf{p}'(t) & \mathbf{M} = \mathbf{L}'(t) \\
\mathbf{p} = m\mathbf{v} & L = J\omega \\
\mathbf{F} = m\mathbf{a} & M = J\alpha \\
P = \langle \mathbf{F}, \mathbf{v} \rangle & P = \langle \mathbf{M}, \omega \rangle \\
E_{\text{kin}} = \frac{1}{2}m|\mathbf{v}|^2 & E_{\text{rot}} = \frac{1}{2}J\omega^2 \\
s = \varphi r & \mathbf{M} = \mathbf{r} \times \mathbf{F} \quad E_{\text{pot}} = mgh \\
v = \omega r & \mathbf{L} = \mathbf{r} \times \mathbf{p} \quad E_{\text{kin}} + E_{\text{pot}} = \text{const.} \\
a = \alpha r & \mathbf{v} = \omega \times \mathbf{r} \quad F = Ds \quad (\text{Feder})
\end{array}$$

**Gleichstrom**

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

**Wechselstrom**

$$\begin{array}{l|l|l}
\underline{U} = \underline{ZI} & \underline{Z} = R + jX & Z^2 = R^2 + X^2 \\
\underline{I} = \underline{YU} & \underline{Y} = G + jQ & R = Z \cos \varphi \\
\underline{S} = \underline{UI} & \underline{S} = P + jB & X = Z \sin \varphi \\
\\ 
\underline{Z} = R & \text{Widerstand} & \omega = 2\pi f \\
\underline{Z} = jX_C & \text{Kondensator} & X_C = -1/(\omega C) \\
\underline{Z} = jX_L & \text{Spule} & X_L = \omega L
\end{array}$$

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

**Allgemeine Gleichungen**

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

**Elektrostatisches Feld**

$$\begin{array}{l|l}
F = \frac{1}{4\pi\epsilon} \frac{Q_1 Q_2}{r^2} & \mathbf{F}_1 = \frac{1}{4\pi\epsilon} Q_1 Q_2 \frac{\mathbf{x}_1 - \mathbf{x}_2}{|\mathbf{x}_1 - \mathbf{x}_2|^3} \\
\mathbf{F} = q\mathbf{E} & Q = CU \quad U = \varphi(B) - \varphi(A) \\
\mathbf{D} = \epsilon\mathbf{E} & \epsilon = \epsilon_0 \epsilon_r \quad W = QU \\
\mathbf{E} = -\nabla\varphi & \\
\epsilon_0 E^2 = 2w_e &
\end{array}$$

**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**

$$\begin{array}{l|l}
\mathbf{F} = q\mathbf{v} \times \mathbf{B} & \Phi = BA \\
F = qvB & \mathbf{B} = \mu\mathbf{H} \\
F = BI l & \mu = \mu_0 \mu_r \\
H = I/(2\pi r) & (\text{Feld um einen geraden Leiter}) \\
B^2 = 2\mu_0 w_m &
\end{array}$$

**Elektrodynamik**

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

**Maxwell-Gleichungen**

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

**Spezielle Relativitätstheorie**

$$\begin{array}{l}
\gamma = \frac{1}{\sqrt{1 - \beta^2}}, \quad \beta = v/c \\
\gamma = \cosh \varphi, \quad \beta\gamma = \sinh \varphi, \quad \beta = \tanh \varphi \\
ct' = \gamma(ct - \beta x), \quad x' = \gamma(x - \beta ct), \quad (y, z)' = (y, z) \\
t = \gamma\tau & E_{\text{kin}} = E - E_0 \\
p = \gamma mv & E_{\text{kin}} = \gamma mc^2 - mc^2 \\
E = \gamma mc^2 & E^2 = (pc)^2 + (mc^2)^2 \\
\\ 
\Lambda_v = \begin{bmatrix} \gamma & -\beta\gamma & 0 & 0 \\ -\beta\gamma & \gamma & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \\
g = \text{diag}(1, -1, -1, -1) \\
(\partial_\mu) = (\partial_{ct}, \partial_x, \partial_y, \partial_z) \\
(\partial^\mu) = (\partial_{ct}, -\partial_x, -\partial_y, -\partial_z)
\end{array}$$

**Optik**

$$\begin{array}{l}
\frac{1}{f} = \frac{1}{g} + \frac{1}{b}, \quad A = \frac{B}{G} = \frac{b}{g} \\
n_1 \sin(\varphi_1) = n_2 \sin(\varphi_2) \\
c_0 = nc
\end{array}$$

**Thermodynamik**

$$\begin{array}{l|l|l}
R = N_A k_B & m = nM & V = nV_m \\
R = R_s M & m = Nm_T & N = nN_A \\
pV = nRT & & \\
\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2} & & \\
Q = mc\Delta T & &
\end{array}$$

**Konstanten**

$$\begin{array}{l}
\epsilon_0 = 8.8542 \times 10^{-12} \text{ C}/(\text{V m}) \\
\mu_0 = 4\pi \times 10^{-7} \text{ H/m} \\
c_0 = 2.9979 \times 10^8 \text{ m/s} \\
e = 1.6022 \times 10^{-19} \text{ C} \\
G = 6.674 \times 10^{-11} \text{ m}^3/(\text{kg s}^2) \\
N_A = 6.0221 \times 10^{23} \text{ mol}^{-1} \\
k_B = 1.3806 \times 10^{-23} \text{ J/K} \\
R = 8.3145 \text{ J}/(\text{mol K}) \\
0 \text{ K} = -273.15^\circ \text{C} \\
u = 1.6605 \times 10^{-27} \text{ kg} \\
h = 6.6261 \times 10^{-34} \text{ Js} \\
\hbar = 1.0546 \times 10^{-34} \text{ Js} \\
\sigma = 5.6704 \times 10^{-8} \text{ W}/(\text{m}^2 \text{K}^4)
\end{array}$$

$$\begin{array}{l}
m_e = 9.1094 \times 10^{-31} \text{ kg} \\
m_p = 1.6726 \times 10^{-27} \text{ kg} \\
m_n = 1.6749 \times 10^{-27} \text{ kg} \\
m_\alpha = 6.6447 \times 10^{-27} \text{ kg}
\end{array}$$