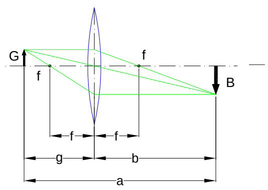
Formelsammlung Physik I und II ETH Zürich

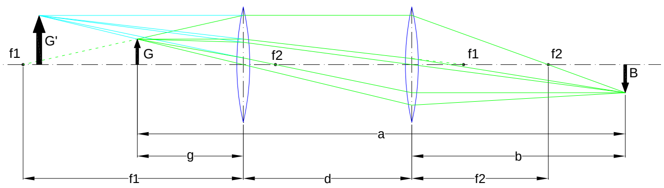
Geschwindigkeit	$v(t) = v_0 + at$	$[x] = m = Länge$
	$x(t) = x_0 + v_0 t + \frac{a}{2}t^2 = \frac{-v_0^2}{2a}$	$[v] = \frac{m}{s} = Geschwindigkeit$
Bremsen	$a(t) = \frac{v}{t}$	$[a] = \frac{m}{s^2} = Beschleunigung$
Oszillator ungedämpft	$a = \frac{Dx}{m} = x_0\omega^2$	$a = \dot{v} = \ddot{x}$
	$x(t) = x_0\cos(\omega t) = x_0\cos\left(\sqrt{\frac{D}{m}}t\right)$	$g = 9.81\frac{m}{s^2}$
	$x(t) = x_0\cos\left(\sqrt{\frac{D}{m}}t\right) + v_0\sqrt{\frac{m}{D}}\sin\left(\sqrt{\frac{D}{m}}t\right)$	$[D] = \frac{N}{m} = \frac{kg}{s^2} = Federkonstante$
Oszillator gedämpft	$a = \frac{-Dx}{m} - c_D v$	$[c_D] = \frac{kg}{s} = Dämpfung$
	$x(t) = \sqrt{x_0^2 + \left(\frac{v_0 + \frac{c_D}{2m}x_0}{\sqrt{\omega_0^2 - \left(\frac{c_D}{2m}\right)^2}}\right)}\, e^{-\frac{c_D}{2m}t}\sin\left(\sqrt{\omega_0^2 - \left(\frac{c_D}{2m}\right)^2}\, t + \varphi_0\right)$	
Eigenfrequenz	$\omega_0 = \sqrt{\frac{D}{m}}$	$A(t) = A_0 e^{-t\sqrt{\omega_0^2 - \omega^2}}$
Resonanzfrequenz	$\omega_R = \sqrt{\omega_0^2 - \frac{c^2}{2m^2}}$	$[\omega] = [f] = \frac{1}{s} = Kreisfrequenz$
Winkelgeschwindigkeit	$\omega = \frac{\varphi}{t} = \frac{b}{rt} = \frac{v}{r}$	$[m] = kg = Masse$
Radiant	$\varphi = \frac{b}{r}$	$360° = 2\pi$
Kraft	$\boldsymbol{F} = ma = m\ddot{x} + \dot{m}\dot{x}$	$[F] = \frac{kg \cdot m}{s^2} = N$
Gravitationskraft	$F_G(x) = \gamma_G \frac{m_1 m_2}{x^2}$	$\gamma_G = 6.674 \cdot 10^{-11}\frac{m^3}{kg \cdot s^2}$
Corioliskraft	$\boldsymbol{F}_C = ma_z = 2m(\boldsymbol{v} \times \boldsymbol{\omega})$	$[r] = m = Radius\ der\ Bahn$
Zentripetal-/Fliehkraft	$\boldsymbol{F}_Z = m\boldsymbol{\omega}^2 r = \frac{mv^2}{r}$	$\boldsymbol{Fettdruck} = Vektor$
Schiefer Wurf	$\boldsymbol{x}(t) = \begin{pmatrix} x \\ y \\ z \end{pmatrix}(t) = \begin{pmatrix} v_0 t\cos\varphi \\ 0 \\ v_0 t\sin\varphi - \frac{g}{2}t^2 \end{pmatrix}$	$\boldsymbol{x} = \begin{pmatrix} x \\ y \\ z \end{pmatrix}$; $\boldsymbol{e}_x = \begin{pmatrix} x \\ 0 \\ 0 \end{pmatrix}$
	$z(x) = x\tan\varphi - \frac{gx^2}{2v_0^2\cos^2\varphi}$	$[\varphi] = rad = Abschusswinkel$
Reibung	$F_R = -\mu_R F_N = -\mu_R mg$	$\mu_R = Haftreibungskoeffizient$
	$F_R = -c_W A\rho\frac{v^2}{2}$	$[\rho] = \frac{kg}{m^3} = Dichte\ des\ Fluids$
Arbeit	$W = Fx = Fx\cos\varphi$	$[W] = Pa \cdot m^3 = N \cdot m = J$
- Beschleunigung	$\mathrm{W} = \mathrm{xma} = \frac{mv^2}{2}$	$[E] = \frac{kg \cdot m^2}{s^2} = W \cdot s = J$
- Hub, Feder	$W = \mathrm{mgh} = \frac{Dx^2}{2}$	$[P] = \frac{J}{s} = \frac{N \cdot m}{s} = W$
Leistung	$P = \frac{W}{t} = \boldsymbol{F}\frac{\boldsymbol{x}}{t}$	$[h] = m = Höhendifferenz$
Energie (potentiell)	$E_{pot} = mgh = \frac{D}{2}x^2$	$1\frac{m}{s} = 3.6\ {}^{km}/_{h}$
Energie (kinetisch)	$E_{kin} = \frac{mv^2}{2} = e_0 U$	$1\ {}^{km}/_{h} = 0.277\overline{7}\frac{m}{s}$
Energie (Trägheit)	$E_{mtr} = \frac{J\omega^2}{2}$	$E_{tot} = E_{kin} + E_{mtr}$
Energie (Licht)	$E_{Licht} = hf = h\frac{c}{\lambda}$	$F_N = Normalkraft$
Impuls	$\sum \boldsymbol{p}_{vorher} = \sum \boldsymbol{p}_{nachher}$	$\boldsymbol{M} = \dot{\boldsymbol{L}}$
	$\boldsymbol{p}(t) = m\boldsymbol{v}(t) = m\dot{\boldsymbol{a}}(t)$	$\dot{\boldsymbol{p}} = \boldsymbol{F}$
Drehimpuls	$\boldsymbol{L} = \boldsymbol{x} \times \boldsymbol{p}$	$[\boldsymbol{p}] = \frac{kg \cdot m}{s} = N \cdot s$
	$L = mvr = m\omega r^2$	$[\boldsymbol{L}] = N \cdot m \cdot s$
Moment	$\boldsymbol{M} = \boldsymbol{x} \times \boldsymbol{F} = \boldsymbol{xF}\sin\varphi$	$[\boldsymbol{M}] = N \cdot m$
Schwerpunkt	$x_s = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$	$J_{massive\ Kugel} = \frac{2}{5}mr^2$
Trägheitsmoment	$J = mr^2 = \rho V r^2 = \rho r^2 \int dV$	$[J] = kg \cdot m^2$

Laminare Strömung	$v_1 = \frac{A_2 v_2}{A_1}$	$[\eta] = \frac{N \cdot s}{m^2} = Viskosität$
	$F_R = \eta A \frac{v}{d}$	$[d] = m = Distanz\ der\ Flächen$
	$v(r) = \frac{p_1 - p_2}{4\eta l} + (d^2 - r^2)$	$[r] = m = Radius\ des\ Rohrs$
Druck	$p = \frac{F}{A} = \rho g h$	$[p] = \frac{N}{m^2} = Pa = 10^{-5} bar$
Durchfluss	$\dot{V} = \frac{\pi(p_1 - p_2)}{8\eta l} r^4$	$[\dot{V}] = \frac{V}{s}$
Ideales Gas	$pV = nRT$	$R = 8.31 \frac{J}{mol \cdot K}$
	$R = kN_A$	$[n] = mol$
Gasdruck	$p = \frac{1}{3}\frac{m}{V} N\overline{v^2} = \frac{1}{3}\rho\overline{v^2}$	$N_A = 6.022 \cdot 10^{23}\ (Teilchen)$
	$\sqrt{\overline{v^2}} = v_m = \sqrt{\frac{3p}{\rho}}$	$0°C = 273.15\ K = 32°F$
Wärmeübertrag	$\Delta Q = mc\Delta T = nC\Delta T$	$[C] = \frac{J}{mol \cdot K}$
Volumenarbeit	$\Delta W = -p\Delta V = -(pA)\Delta x$	$[c] = \frac{J}{kg \cdot K}$
Innere Energie	$\Delta U = \Delta W + \Delta Q$	$\Delta W, \Delta Q\ sind\ Wegabhängig$
Adiabatische Arbeit	$\Delta W = -nRT \ln\left(\frac{V_2}{V_1}\right) = -nRT \int_{V_1}^{V_2} \frac{1}{V} dV$	$isotherm \rightarrow arbeit\ am\ Gas$
	$\Delta Q = -\Delta W = p_1(V_2 - V_1)\frac{V_1}{V_2}$	$adiabatisch: \Delta U = \Delta W, \Delta Q = 0$
Isochore Arbeit	$\Delta U = \Delta Q = nC_{mV}\Delta T$	$isoterme\ Kompression\ \Delta U = 0$
Wärmekapazität	$U = N\frac{f}{2}kT = n\frac{f}{2}RT$	$f = Freiheitsgrade$
- Isochor	$C_{mV} = \frac{f}{2}R$	$Einatomig: f = 3$
	$dU = nC_{mV}dT$	$Zweiatomig, starr: f = 5$
- Isobar	$C_{mp} = \left(\frac{f}{2} + 1\right)R$	$Zweiatomig, schwingend: f = 7$
Wirkungsgrad	$\eta = \frac{W}{Q} = \frac{\lvert geleistete\ Arbeit \rvert}{verbrauchte\ Energie}$	$Mehratomig, starr: f = 6$
- Wärmepumpen	$\eta = \frac{Q}{W}$	$[\Delta Q] = [\Delta U] = [\Delta W] = J$
Wärmekraftmaschine	$\eta_{reversibel} > \eta_{irreversibel}$	$[S] = \frac{J}{K}$
- max.	$\eta_{rev}^{WKM} = 1 - \frac{T_k}{T_h}$	$[T_k] = K = Temp.kaltes\ Res.$
	$\frac{Q_{out}}{T_k} + \frac{Q_{in}}{T_h} = 0$	$[T_h] = K = Temp.warmes\ Res.$
Entropie	$\Delta S = \frac{\Delta Q_{rev}}{T} = \int_1^2 \frac{dQ}{T} = \int_1^2 \frac{f}{2}\frac{nR}{T} dT$	$\Delta S = \oint \frac{dQ_{rev}}{T} = 0$
Phasenumwandlung	$Q_s = c_s m$	$c_s(H_2O) = 333'700 \frac{J}{kg}$
	$Q_v = c_v m$	$c_v(H_2O) = 2'256'000 \frac{J}{kg}$
Wärmekapazität	$Q = c_W mT$	$c_W(H_2O) = 4'187 \frac{J}{kg \cdot K}$
Luftfeuchtigkeit	$\varphi_{LF} = \frac{p_{air}}{p_{sat}} = \frac{Dampfdruck}{Sättigungsdampfdruck}$	$[\varphi_{LF}] = \%\ ; 100\% = Taupunkt$
Wärmeleitung	$\dot{Q} = \frac{Q}{t} = \lambda\frac{A}{x}(T_h - T_k)$	$[\dot{Q}] = \frac{J}{s} = W\ ; [\lambda] = \frac{W}{m \cdot K}$
- Doppelwand	$\dot{Q} = \frac{1}{\frac{x_1}{A\lambda_1} + \frac{x_2}{A\lambda_2}}(T_h - T_k)$	$[T_k] = K = Temp.kaltes\ Res.$
	$\lambda_1 = \lambda_2 \frac{x_1(T_m - T_k)}{x_2(T_h - T_m)}$	$[T_h] = Temp.warmes\ Res.$
- k-Wert	$k = \frac{\lambda}{x}$	$k_{ideal} = \frac{1.3W}{0.2m \cdot m \cdot K} = 6.5 \frac{W}{m^2 \cdot K}$
- Konvektion	$\dot{Q} = \alpha A(T_{Luft} - T_{Wand})$	$\alpha_{inn} \approx 8 \frac{W}{m^2 \cdot K}\ ;\ \alpha_{auss} \approx 25 \frac{W}{m^2 \cdot K}$
- k-Wert total Wand	$k_{tot} = \frac{1}{\frac{1}{\alpha_{inn}} + \frac{1}{\lambda_{Wand}} + \frac{1}{\alpha_{auss}}}$	$[k] = [\alpha] = \frac{W}{m^2 \cdot K}$
Wärmestrahlung	$E_S(\lambda, T) = \frac{2\pi c^2 h}{\lambda^5} \frac{1}{e^{\frac{hc}{\lambda kT}} - 1}$	$h = 6.6262 \cdot 10^{-34} J \cdot s$
	$\lambda_{max} = \frac{c_W}{T} = \frac{2.898 \cdot 10^{-3} m \cdot K}{T}$	$c = 2.998 \cdot 10^8 \frac{m}{s}\ (Lichtgesch.)$

Stromstärke	$I = \frac{q}{t} = v_D A n e_0$	$v_D = Driftgeschwindigkeit$
	$q = tI$	$[I] = \frac{C}{s} = A$
Coulombkraft	$\boldsymbol{F}_{C(1\leftrightarrow2)} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{(x_1-x_2)^2}\frac{(x_1-x_2)}{\lvert x_1-x_2\rvert}$	$[q] = A\cdot s = C$
Elektrisches Feld	$\boldsymbol{E}(\boldsymbol{x}) = \frac{1}{4\pi\varepsilon_0}\sum_i \frac{q}{(x-x_i)^2}\frac{(x-x_i)}{\lvert x-x_i\rvert}$	$\varepsilon_0 = 8.854\cdot 10^{-12}\frac{C^2}{N\cdot m^2}$
- Punktladung	$E = \frac{q}{4\pi\varepsilon_0}$	$e_0 = 1.602\cdot 10^{-19}C$
- Fernfeld Dipol	$E = \frac{2rq}{4\pi\varepsilon_0 x^3}$	$\vec{E}$ Richtung ist e^+ Bewegung
- Flächenladung	$E = \frac{\sigma}{2\varepsilon_0}$ (unabhängig vom Abstand!)	$[\sigma] = \frac{C}{A}$ = Ladungsdichte
- Linienladung	$E = \frac{\varrho}{4\pi\varepsilon_0}$	$[\varrho] = \frac{C}{m}$ = Ladungsdichte
- Plattenkondensator	$E = \frac{U}{d} = \frac{q}{\varepsilon_0 A}$	$q(e^-) = q(Proton) = e_0$
Elektrostatische Arbeit	$W_{(1\to2)} = -q\int_1^2 \boldsymbol{E}(\boldsymbol{x})\,d\boldsymbol{x}$	$[E] = \frac{N}{C} = \frac{\frac{kg\cdot m}{s^2}}{C} = \frac{V}{m}$
Spannung, Potentialdiff.	$U_{(1\to2)} = \frac{W_{(1\to2)}}{q} = -\int_1^2 \boldsymbol{E}(\boldsymbol{x})\,d\boldsymbol{x}$	$[U] = \frac{J}{C} = V$
	$\Phi(x) = U(x) = \frac{q}{4\pi\varepsilon_0 x}$	Definition Stromflussrichtung
Energie kinetisch	$E_{kin(1\to2)} = qU_{(1\to2)} = \frac{mv^2}{2}$	· Elektronenfluss: von − zu +
	$v = \sqrt{\frac{2qU_{(1\to2)}}{m}}$	· technisch: von + zu −
Energie potentiell	$E_{pot} = \frac{1}{4\pi\varepsilon_0 d}(q_1q_2 + q_1q_3 + q_2q_3)$	d = Abst. drei Punktladungen
Wiederstand	$R = \frac{U}{I} = \rho\frac{x}{A}$	$[R] = \frac{V}{A} = \Omega$
- Parallel	$R_{tot} = \frac{1}{\frac{1}{R_1}+\frac{1}{R_2}}$	$[\rho] = \frac{\Omega m^2}{m} = \Omega m$
- Seriell	$R_{tot} = R_1 + R_2$	$\mu_0 = 4\pi\cdot 10^{-7}\frac{N}{A^2}$
El. Leistung	$P = \frac{qU}{t} = UI = I^2R$	$[P] = \frac{J}{s} = \frac{N\cdot m}{s} = \frac{kg\cdot m^2}{s^3} = W$
Wechselstrom	$U(t) = \hat{U}\cos(\omega t)$	$\hat{U}$ = max. Amplitude U
	$I(t) = \frac{U(t)}{R} = \frac{\hat{U}}{R}\cos^2(\omega t) = \hat{I}\cos(\omega t)$	$\hat{I}$ = max. Amplitude I
- Leistung	$P(t) = \hat{U}\hat{I}\cos^2(\omega t) = \frac{\hat{U}^2}{R}\cos^2(\omega t)$	$1eV = 1.602\cdot 10^{-19}J$
- Effektivwerte	$U_{eff} = \frac{\hat{U}}{\sqrt{2}}$	$1kWh = 3.6\cdot 10^6 J = 3600kWs$
	$I_{eff} = \frac{\hat{I}}{\sqrt{2}}$	
	$P_{eff} = \bar{P} = \frac{\hat{U}\hat{I}}{2} = \frac{\hat{U}^2}{2R} = \frac{R\hat{I}^2}{2}$	
- Transformator	$U_{ind} = -\dot{\phi}(t) = -N\dot{\phi}(t)$	
	$U_1(t) = \frac{-N_1}{N_2}U_2(t)$	
Kraft auf elektr. Leiter	$d\boldsymbol{F}_{(1\leftrightarrow2)} = \frac{\mu_0}{4\pi}\frac{I_1 d\boldsymbol{x}_1\times\{I_2 d\boldsymbol{x}_2\times(\boldsymbol{x}_1-\boldsymbol{x}_2)\}}{\lvert\boldsymbol{x}_1-\boldsymbol{x}_2\rvert^3}$	γ = Wegparametrierung
	$d\boldsymbol{F}_{(1\leftrightarrow2)} = I_1 d\boldsymbol{x}_1\times d\boldsymbol{B}(\boldsymbol{x}_1)$	$[B] = \frac{N}{A\cdot m} = \frac{N\cdot m}{A\cdot m^2} = \frac{J}{A\cdot m^2} = T$
Magnetfeld	$\boldsymbol{B}(\boldsymbol{x}) = \frac{\mu_0}{4\pi}\int_\gamma \frac{Id\boldsymbol{x}\times(\boldsymbol{x}-\boldsymbol{x}_\gamma)}{\lvert\boldsymbol{x}-\boldsymbol{x}_\gamma\rvert^3}$	$[B] = \frac{W\cdot s}{A\cdot m^2} = \frac{V\cdot s}{m^2} = T$
- gerader Leiter	$\boldsymbol{B}(r) = \frac{\mu_0 I}{2\pi r}\boldsymbol{e}$	$\boldsymbol{e}$ = Einheitsvektor
- in Spuhle	$B = \mu_0 I\frac{N}{x}$	N = Anzahl Windungen
- Lorentzkraft	$d\boldsymbol{F}_L = Id\boldsymbol{x}\times\boldsymbol{B}(\boldsymbol{x})$	
	$\boldsymbol{F}_L = q\boldsymbol{v}\times\boldsymbol{B}$	$\boldsymbol{n} = \vec{n}$ = Flächennormale
- F_L in Kreisbahnen	$r = \frac{mv}{qB}$	$[\boldsymbol{m}] = A\cdot m^2$
	$\omega = \frac{qB}{m}$	$[\omega] = s^{-1}$ = Zyklotronfreq.
Leiterschleife Moment	$\boldsymbol{m} = IA\boldsymbol{n}$	$[A] = m^2$ = Fl. Leiterschleife

	$\boldsymbol{M} = \boldsymbol{m} \times \boldsymbol{B} = IA\boldsymbol{n} \times \boldsymbol{B}$	$\boldsymbol{n} = Normale\ zur\ Fläche$
Hall-Spannung	$U_H = v_D Bb = A_H \frac{IB}{d}$	$A_H = \frac{1}{ne_0} = Hall\ Konstante$
Magnetische Induktion	$\phi_M = \int_A \boldsymbol{B}(\boldsymbol{r})dA = NB\pi r^2 = NBA$	$[\phi] = T \cdot m^2 = V \cdot s$
Magnetischer Fluss	$U_{ind} = \frac{-d\phi(t)}{dt} = -\dot{\phi}(t)$	$[r] = m = Radius\ der\ Schleife$
	$U_{ind}(t) = l2rB\omega \sin(\omega t) = U_0 \sin(\omega t)$	$[l] = m = Länge\ der\ Schleife$
Elektrische Leistung	$P_{ind} = UI = F_L v = lvBI$	$\boldsymbol{S} = Eigendrehimpuls\ (Spin)$
Magn. Moment des e-	$\boldsymbol{m}_{Bahn} \cong \frac{-e_0}{2m_{e^-}}\boldsymbol{L}\ ; \boldsymbol{m}_{Spin} = \frac{-e_0}{2m_{e^-}}\boldsymbol{S}$	$m_{e^-} = 9.109 \cdot 10^{-31} kg$
	$\boldsymbol{m} = \boldsymbol{m}_{Bahn} + \boldsymbol{m}_{Spin} \cong \frac{-e_0}{2m_{e^-}}(\boldsymbol{L} + 2\boldsymbol{S})$	$\sum aller\ \boldsymbol{m} \Rightarrow Magnetisierung$
Magnetisierung	$\boldsymbol{B}_M = \mu_0 \boldsymbol{M}$	
	$B(r) = \frac{\mu_0 I}{2\pi r}$	
Brennpunkt	$f = \frac{r}{2} = \frac{bg}{b+g}$	$[f] = m = Brennpunkt$
Abbildungsgrösse	$\frac{1}{f} = \frac{1}{g} + \frac{1}{b}$	$[g] = m = Gegenstandsabst.$
	$b^2 - ba + fa = 0$	$[b] = m = Bildabst.$
Vergrösserung	$\beta = \frac{b}{g} = \frac{b-f}{f} = \frac{B}{G}$	$[a] = m = Abstand\ Bild\ Objekt$
Brechungsindex	$n_{Medium} = \frac{c_{Vakuum}}{c_{Medium}} \geqq 1$	$[G] = m = Gegenstandsgrösse$
	$\frac{\sin\varphi_1}{\sin\varphi_2} = \frac{c_1}{c_2} = \frac{n_2}{n_1}$	$[B] = m = Bildgrösse$
	$\varphi_{1,krit} = \frac{n_2}{n_1}$	$Totalreflexion: \varphi_{krit} < \varphi$
Zwei Linsen	$\frac{1}{b} = \frac{1}{f_2} - \frac{f_1 g}{f_1 g + d(f_1 - g)}$	$[d] = m = Linsenabstand$





Dioptrien	$D = \frac{1}{f}$	$[D] = \frac{1}{m} = dpt$
Sehwinkel	$\tan\varepsilon = \frac{g}{s}$	$s_0 = 0.25m$
Lupe	$\tan\varepsilon_{ohne} = \frac{g}{s_0}$	
Vergrösserung	$\Gamma = \frac{\tan\varepsilon_{mit}}{\tan\varepsilon_{ohne}} = \frac{s_0}{g_{mit}} = \frac{s_0}{f}$	$falls\ \lvert Auge - Linse\rvert \ll b$
Mikroskop	$\Gamma = \frac{\tan\varepsilon_{mit}}{\tan\varepsilon_{ohne}} = \frac{s_0 d}{f_{Okular} f_{Objektiv}}$	$[d] = m = Tubuslänge$
Wellen	$\Psi(x,t) = A\cos(kx - \omega t - \varphi)$	$[A] = m = Amplitude$
	$f = \frac{1}{T}$	$[k] = \frac{1}{m} = Wellenzahl$
	$\lambda = \frac{2\pi}{k}$	$[\lambda] = m = Wellenlänge$
	$T = \frac{2\pi}{kc}$	$[T] = s = Periode$
	$c = \frac{\lambda}{T} = \lambda f$	$[c] = \frac{m}{s} = Wellengeschw.$
	$\omega = \frac{2\pi}{T} = 2\pi f$	$[f] = \frac{1}{s} = Frequenz$
Ausbreitungsgeschw.	$v_{max} = A\omega = A\frac{2\pi c}{\lambda}$	$\varphi = Phasenverschiebung$
Interferenz	$r_1 - r_2 = n\lambda\ mit\ n = 0, \pm 1, \pm 2, \cdots$	$konstruktive\ Interferenz$
	$r_1 - r_2 = (2n+1)\frac{\lambda}{2}\ mit\ n = 0, \pm 1, \pm 2, \cdots$	$destruktive\ Interferenz$
	$\Psi_{tot}(r_1, r_2, t) = 2A_0 \cos\left(k\frac{r_1 - r_2}{2}\right)\cos\left(k\frac{r_1 - r_2}{2} - \omega t\right)$	
Interferenzwinkel	$\alpha = \frac{n\lambda}{d}\ mit\ n = 0, \pm 1, \pm 2, \cdots$	$konstruktive\ Interferenz$
Beugung	$\sin(\alpha_{1min}) = \frac{\lambda}{d}$	$[d] = m = Spaltöffnung$

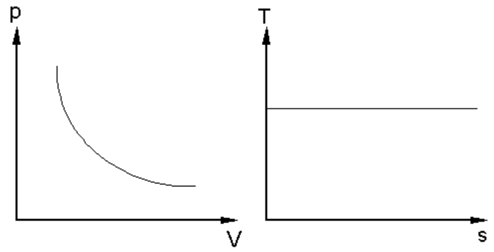
$Q = Wärme$
$W = Arbeit$
$U = Innere\ Energie$

Gaskonstante $R = 8.31 \frac{J}{mol \cdot K}$

Zustandsgrössen
$U = W + Q$
$U = n\frac{f}{2}RT$

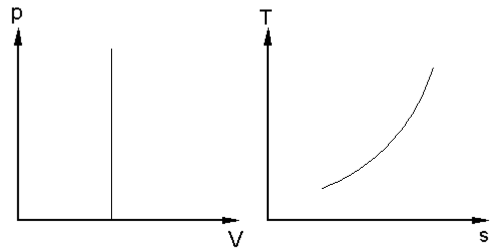
Isotherm
$n, T = konst.$
$pV = konst.$

$Q_{1\to2} = W_{1\to2}$
$Q_{1\to2} = nRT \ln\frac{V_2}{V_1}$
$W_{1\to2} = p_1V_1 \ln\frac{V_1}{V_2} = p_1V_1 \ln\frac{p_2}{p_1}$



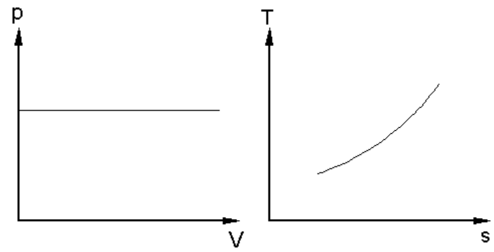
Isochor
$n, V = konst.$
$\frac{p}{T} = konst.$

$Q_{1\to2} = U_2 - U_1$
$Q_{1\to2} = nC_{mV}(T_2 - T_1)$
$W_{1\to2} = 0$



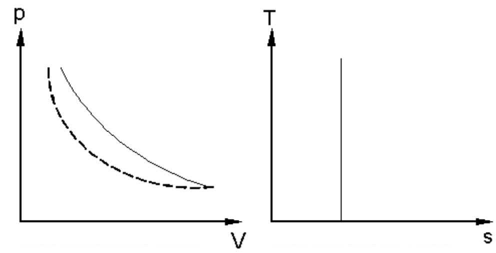
Isobar
$n, p = konst.$
$\frac{V}{T} = konst.$

$U_2 - U_1 = Q_{1\to2} + W_{1\to2}$
$Q_{1\to2} = nC_{mp}(T_2 - T_1)$
$W_{1\to2} = p(V_1 - V_2)$



Adiabatisch
$n = konst.$
$pV^\kappa = konst.$
$TV^\kappa = konst.$
$\Delta Q = 0$

$W_{1\to2} = U_2 - U_1$
$W_{1\to2} = -p_1(V_2 - V_1)\frac{V_1}{V_2}$
$W_{1\to2} = nC_{mV}(T_2 - T_1)$
$W_{1\to2} = -nRT \ln\frac{V_2}{V_1}$
$Q_{1\to2} = 0$
$p_2 = p_1\left(\frac{V_1}{V_2}\right)^\kappa$



Wärmekapazität
$\kappa = \frac{C_{mp}}{C_{mV}}$
$C_{mV} = \frac{f}{2}R$
$C_{mp} = \left(\frac{f}{2} + 1\right)R$

Freiheitsgrade
$Einatomig\ f = 3$
$Zweiatomig, starr\ f = 5$
$Zweiatomig, schwingend\ f = 7$
$Mehratomig, starr\ f = 6$