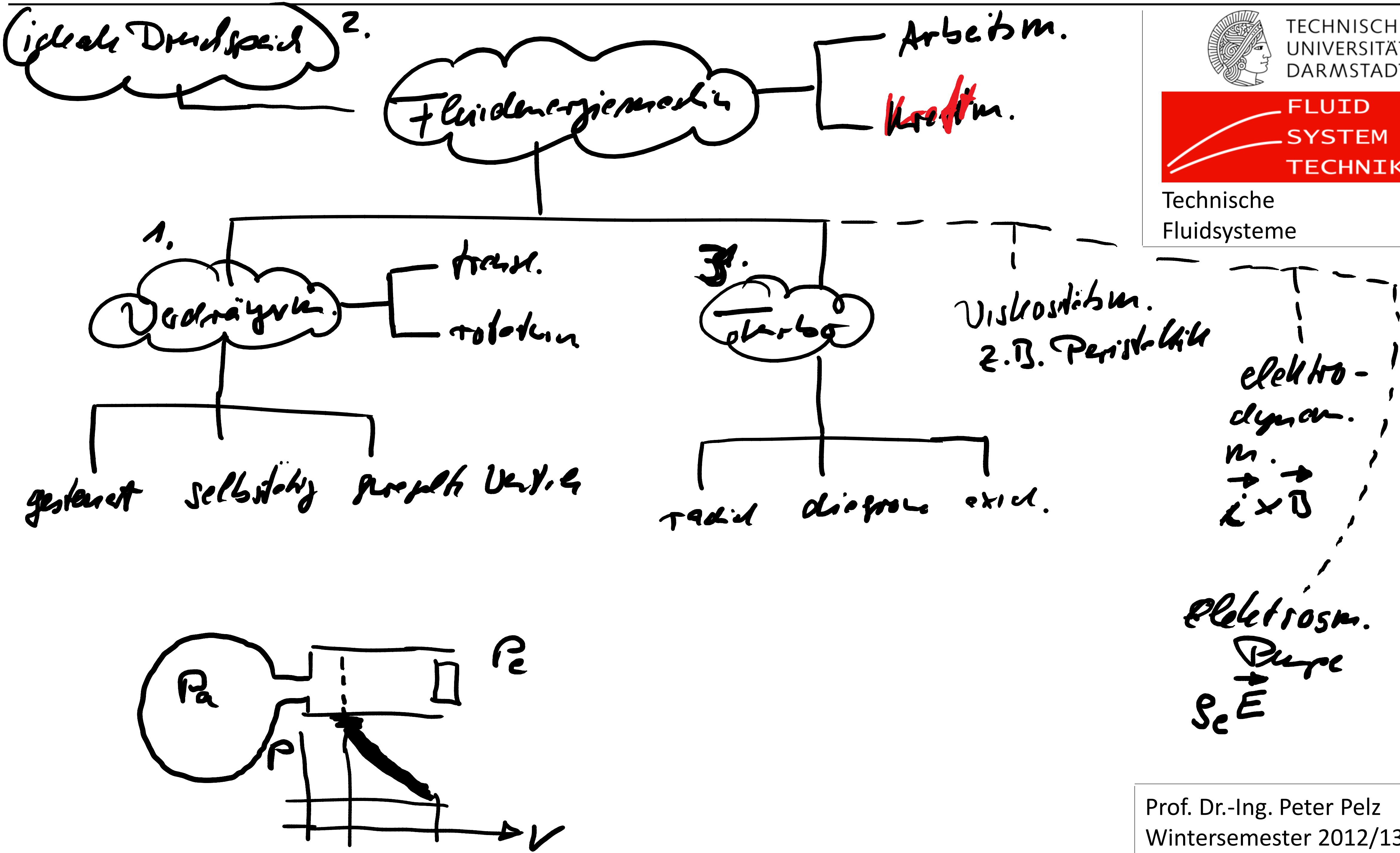

Technische Fluidsysteme

Prof. Dr.-Ing. Peter Pelz

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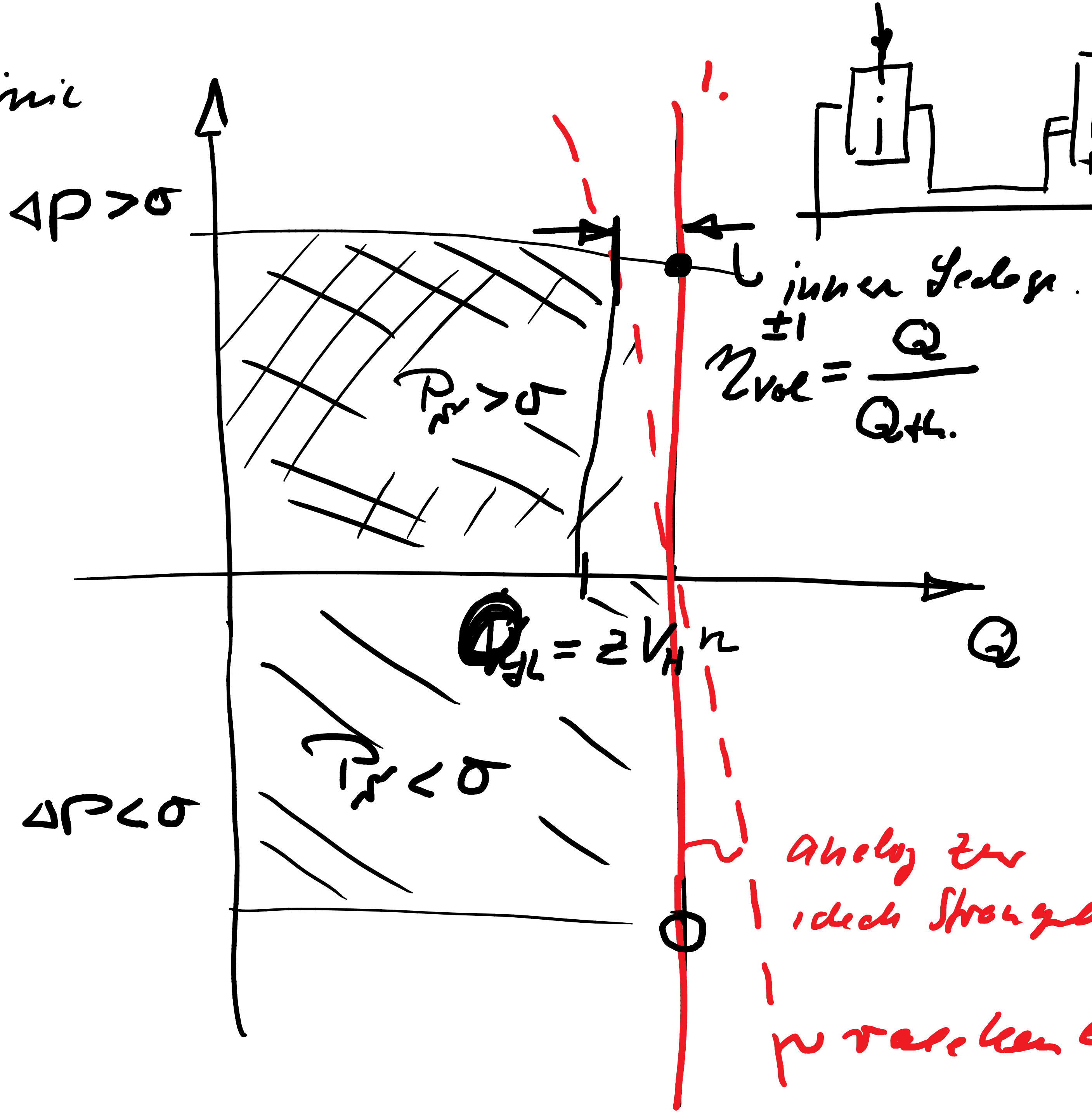
FLUID SYSTEM TECHNIK
Technische Fluidsysteme

Kennlinie

Arbeitsm. $P > 0$



z Zahl der Arbeitsräume

V_H Hubvolumen

$n = \frac{1}{T} = \frac{\Omega}{2\pi}$ Drehzahl

Kraftmaschine ⇒ Motor

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$$\eta_{vol}^{\pm 1} := \frac{Q}{Q_{th}}$$

+1 Arbeitsm.

−1 Kraftmaschine od. Motor.

$$\eta^{\pm 1} := \frac{\Delta p \, Q}{M \Omega}$$

$$= \underbrace{\frac{\Delta p V_H z_*}{M 2\pi}}_{\eta_M} \; \underbrace{\frac{Q}{z V_H n}}_{\eta_{vol}}$$

η_M mechanischer Wirkungsgrad

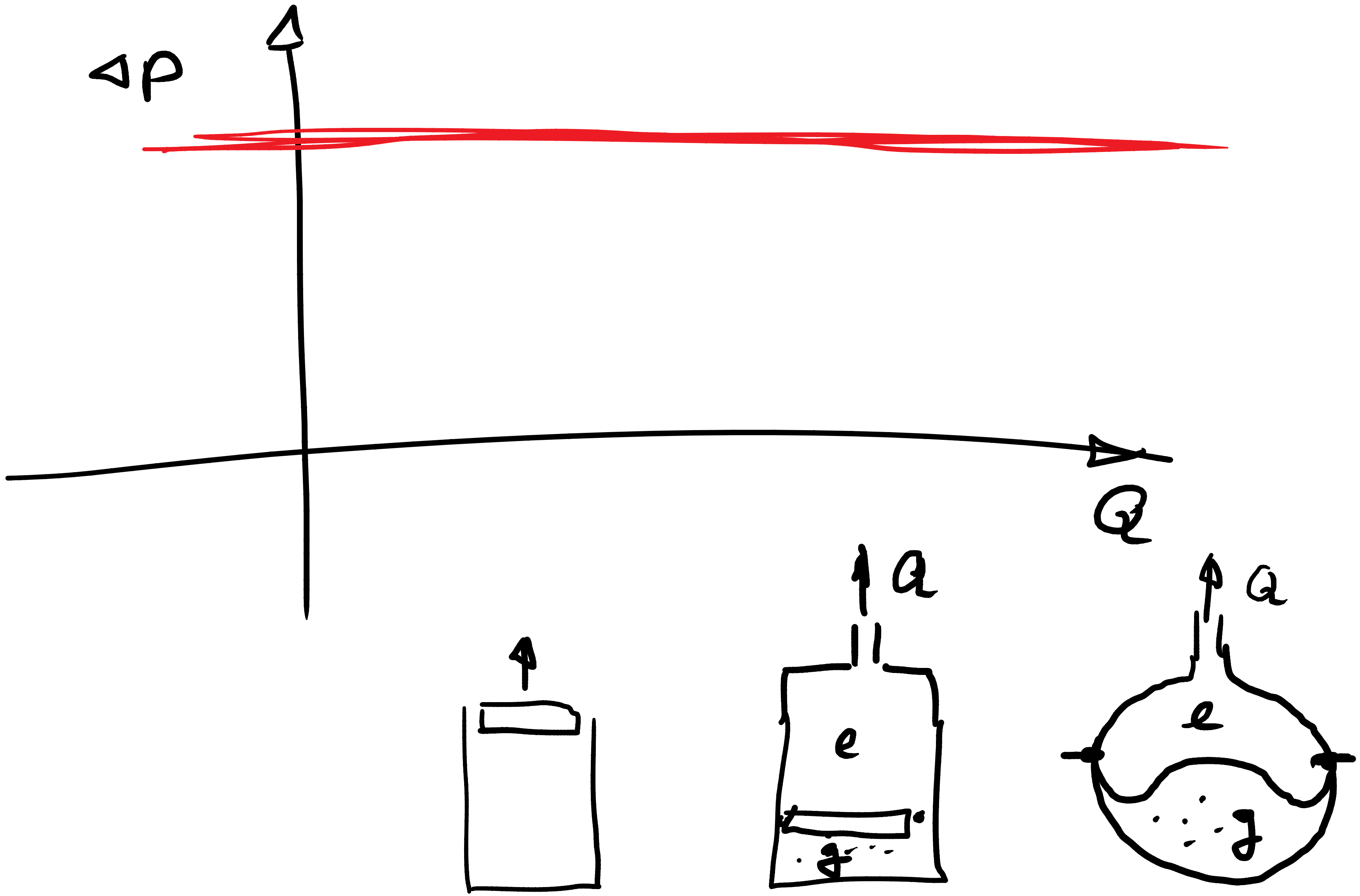
η_{vol} volumetrischer Wirkungsgrad

$P_S = \vec{M} \cdot \vec{\Omega}$ Wellenleistung

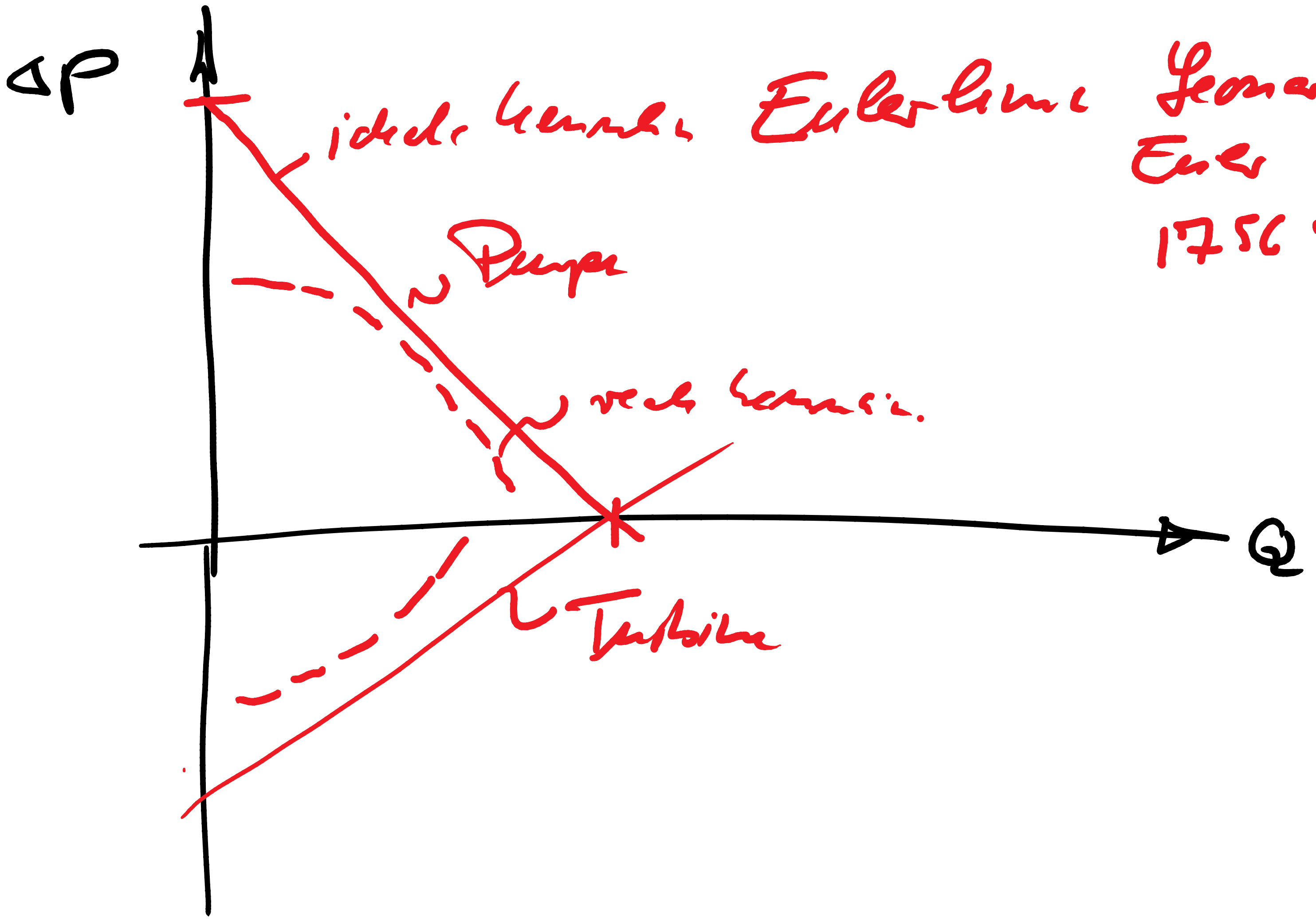
$\nabla \hat{=}$ technische Arbeit / Zeit Δ

Prof. Dr.-Ing. Peter Pelz

Zu 2. Kennlinie einer idealen Druckspeicher



3. Turbomaschine.



Leonard Euler
1756 Drallsatz

1. Erster Hauptsatz (Helmholtz)

$$\dot{m}\left(h_{t2} - h_{t1}\right) = P_S + \dot{Q} \quad \text{für } \frac{\partial}{\partial t} \equiv 0$$

$$P_S = \vec{M} \cdot \vec{\Omega} = M_z \Omega$$

$\dot{m} = \rho Q$ Massenstr.

$h_t = \frac{u^2}{2} + \frac{p}{\rho} + \psi + e$ Absolutenthalpie

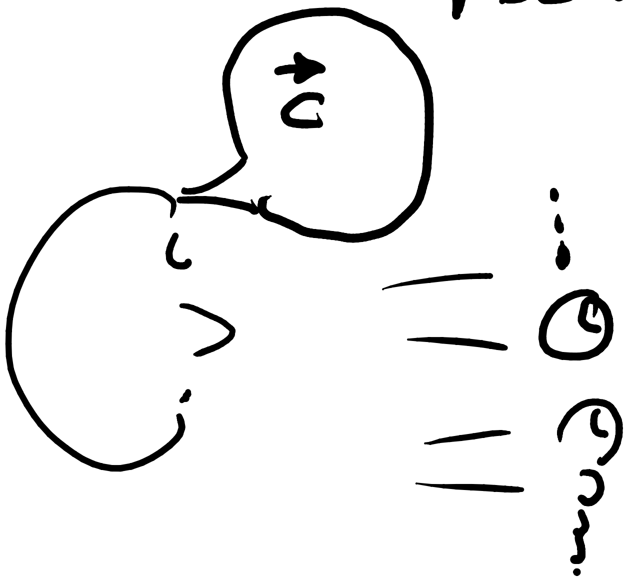
$\dot{Q}$ Wärmestrom $\equiv 0$ (adiabates System)

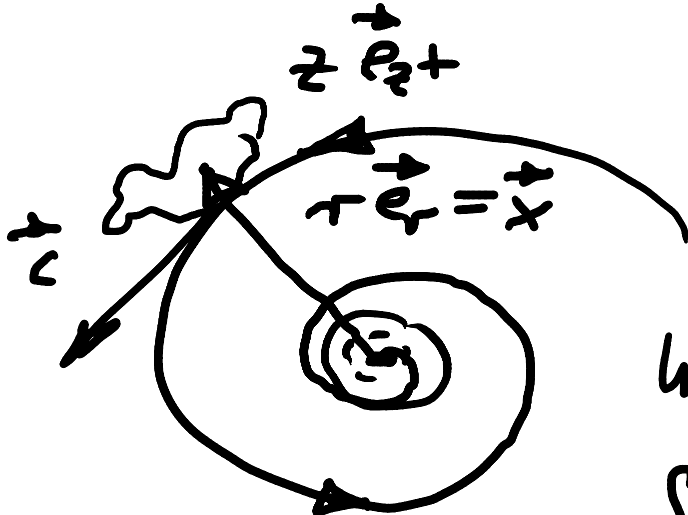
2. Drallsatz (z-Komp., $\frac{\partial}{\partial t} \equiv 0$)

$$\dot{m}\left(r_2 c_{u2} - r_1 c_{u1}\right) = M_z$$

$$(\vec{x} \times \vec{c}) \cdot \vec{e}_z = r c_u$$

Axialkomponente des massenspez. Dralls eines Flüssigkeitsteilch.





Wirbelsenke = Senke + Potentialwirbel.

$\vec{c}$ Absolutgeschwindigkeit

$\vec{w}$ Relativgeschw.

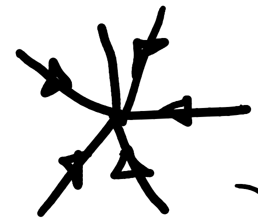
$\vec{u}$ Umfangsgeschw.

$$\vec{c} = c_r \vec{e}_r + c_u \vec{e}_\varphi + c_z \vec{e}_z$$

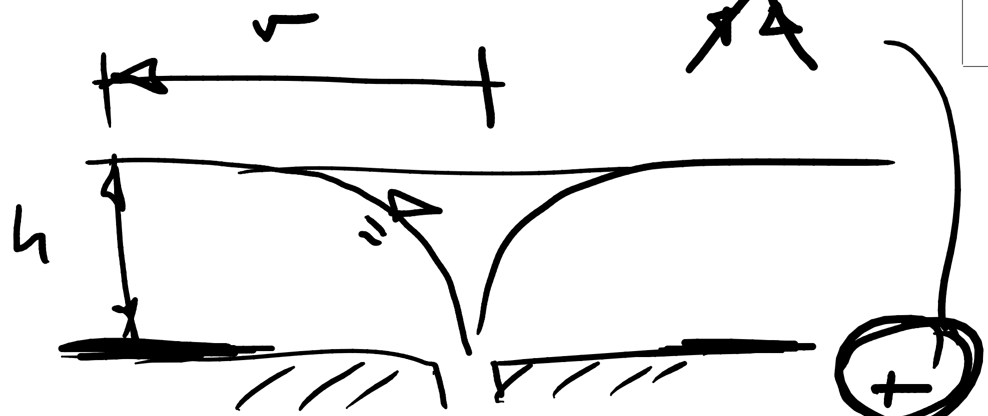
$u \to \varphi$

Wirbelsenke

$$c_r = -\frac{Q}{2\pi r h}$$ Senke.



$$\vec{c} = -\frac{Q}{2\pi r h}\vec{e}_r + \frac{\Gamma}{2\pi r}\vec{e}_\varphi$$



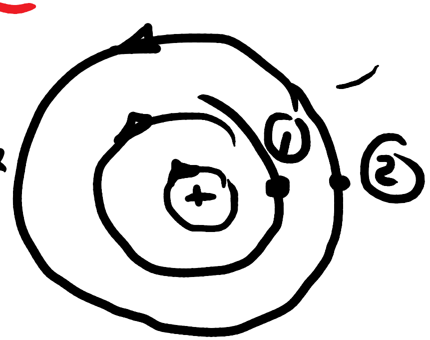
$$\frac{d\vec{x}}{ds} = \frac{\vec{c}}{|\vec{c}|}$$

⇒ logarithmische Spirale.

$$c_u = \frac{\Gamma}{2\pi r}$$ Potentialwirbel

$$c_u r = \frac{\Gamma}{2\pi} = const.$$

wenn kein Moment auf das Element wirkt.



$$\dot{m}\left(r_2 c_{u2} - r_1 c_{u1}\right) = M_t \overset{!}{=} 0$$

$$\Rightarrow r_2 c_{u2} = r_1 c_{u1}$$

1. HS $h_{t2} - h_{t1} = \frac{P_S}{\dot m} = w_t$

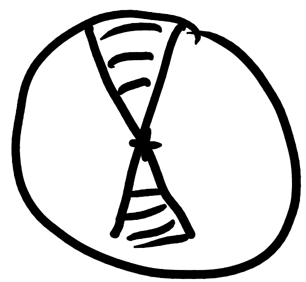
$\dot Q = 0$

$\frac{\partial}{\partial t} = 0.$

Drallsatz $u_2 c_{u2} - u_1 c_{u1} = \frac{P_S}{\dot m}$;

$\frac{\partial}{\partial t} = 0.$

Umfangsgeschw. $u = r\Omega$



$h_{t2} - h_{t1} = u_2 c_{u2} - u_1 c_{u1}$

Energieerh. — Kinematik

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Totalenthalpie = $\frac{\text{Druck}}{\text{Dichte}}$ + $\frac{\text{Geschw}^2}{2}$ + innere Energie + Potential

$$= \frac{p}{\rho} + \frac{c^2}{2} + e + \psi$$

$\psi = gz$

$$h_{t2} - h_{t1} = \left[\frac{p}{\rho} + \frac{c^2}{2} + \psi\right]_2 - \left[\frac{p}{\rho} + \frac{c^2}{2} + \psi\right]_1 + (e_2 - e_1)$$

$$G_2 - G_1 := gH$$

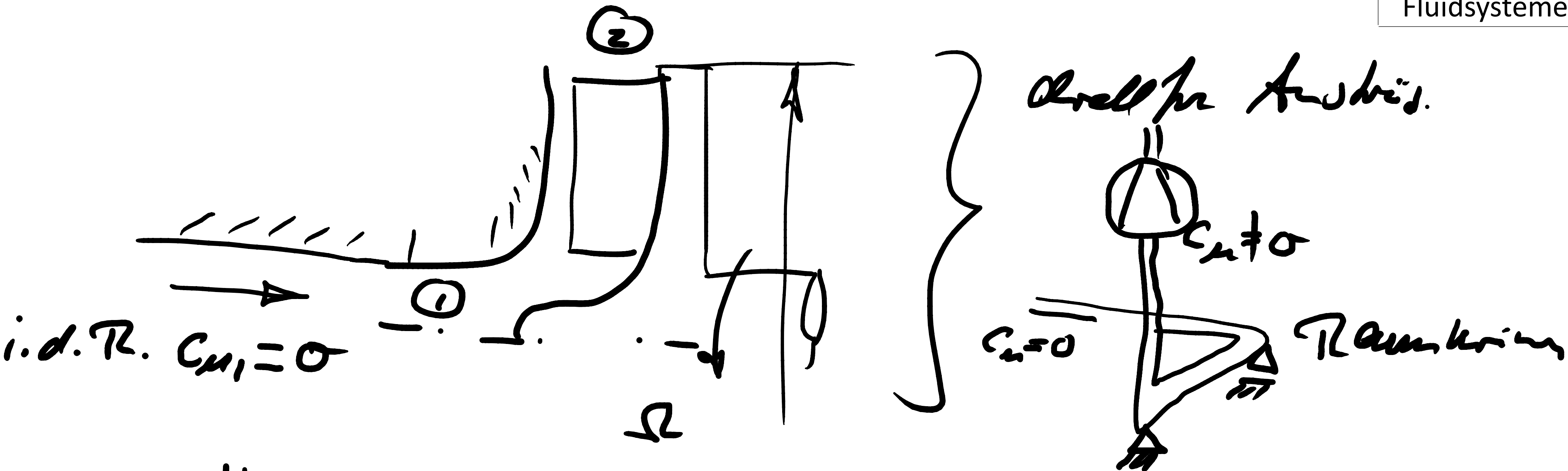
$H > 0$ Arbeiten

$H < 0$ Kraftmaschine.

Förderhöhe oder Fallhöhe.

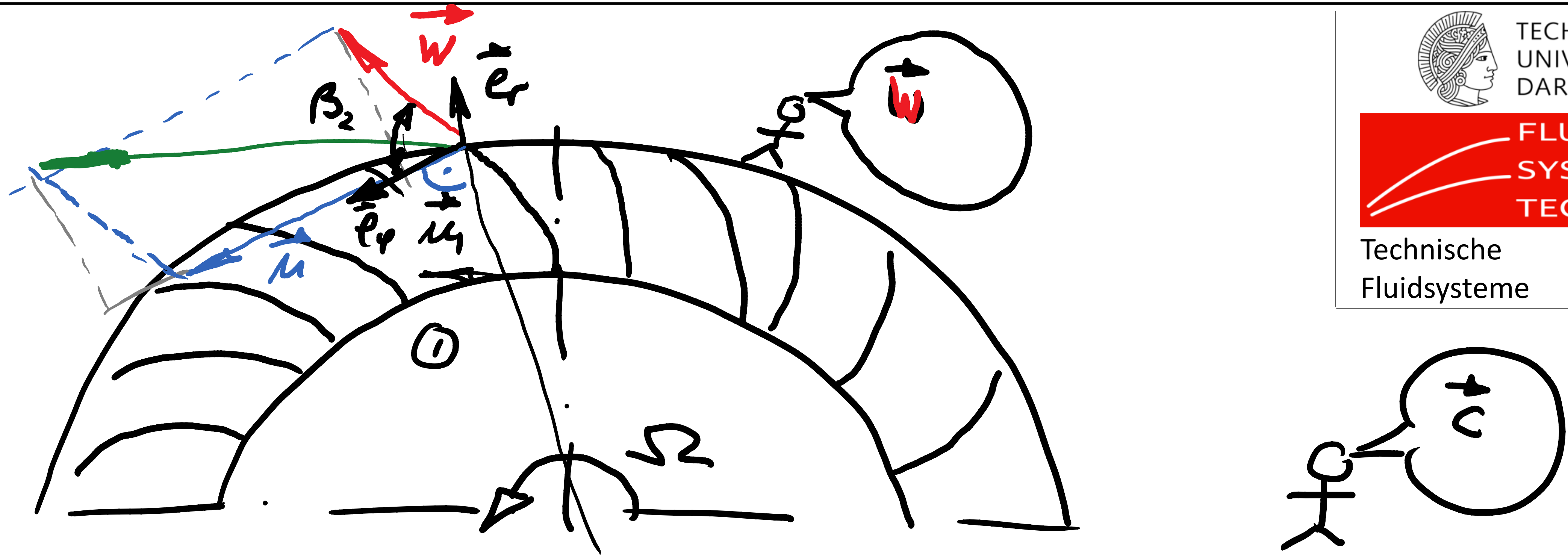
C Bernoullische Konstante

$$gH + (e_2 - e_1) = u_2 c_{u2} - u_1 c_{u1} \quad \Big| \; \frac{1}{u_2^2}$$

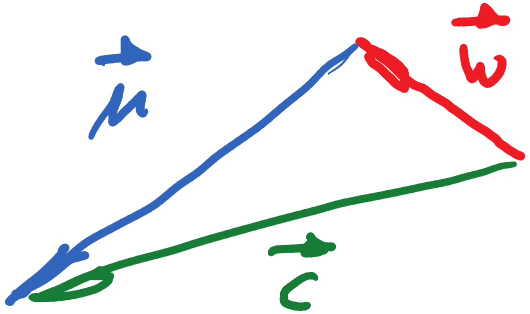


$$\frac{gH}{u_2^2} + \frac{e_2 - e_1}{u_2^2} = \frac{c_{u2}}{u_2} - \frac{r_1}{r_2}\frac{c_{u1}}{u_2} = \frac{c_{u2}}{u_2}$$ für drallfreie Zustr.

$\frac{gH}{u_2^2} = \psi$ Druckziffer. $\quad \frac{e_2 - e_1}{u_2^2} = \psi_V$ Verlust an Druckziffer durch innere Reibung



$$\vec{u} = r\Omega\,\vec{e}_\varphi\,.$$



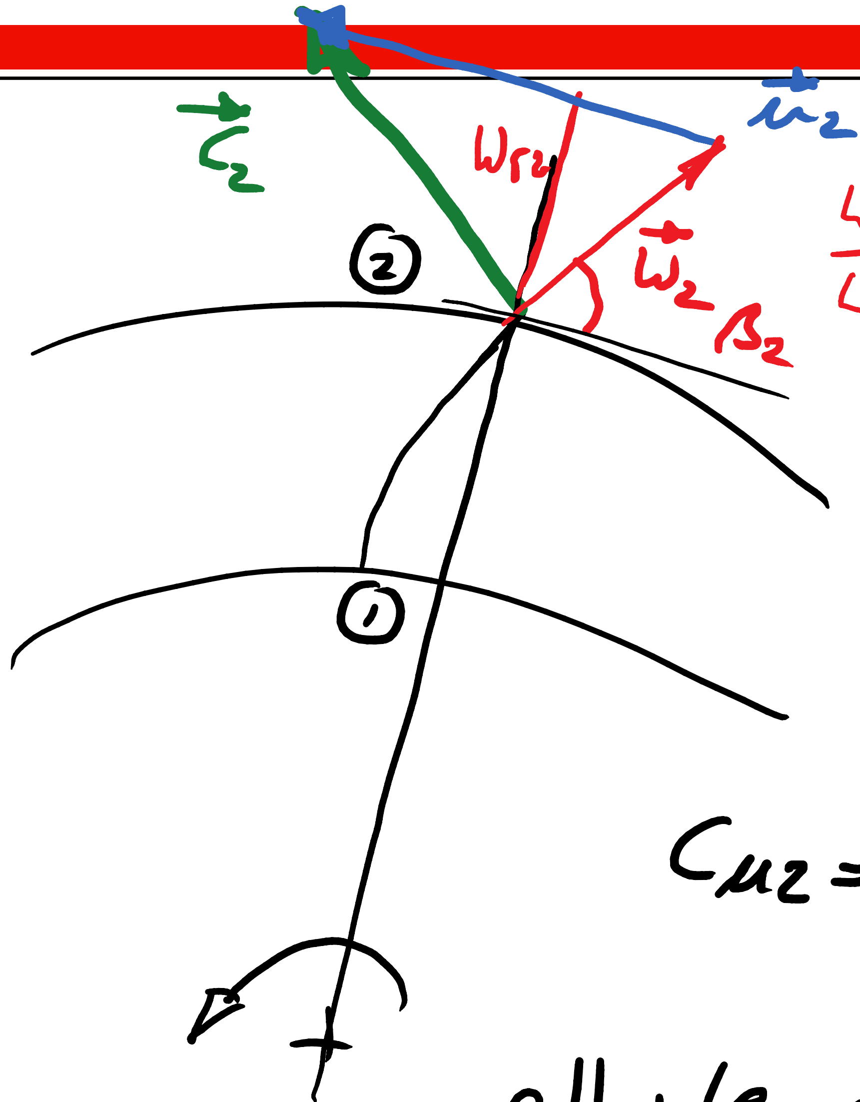
Geschwindigkeitsdreieck.

$$\vec{c} = \vec{w} + \vec{u} \;\left(+ \vec{v} \right)$$

rel. Geschw. — Umfangsg. — Führungsgeschw.

$$c_u = \Omega r_2 + w_{r_2} \cot\beta_2$$

$$c_r = -\frac{Q}{2\pi r h}$$



$$\frac{w_{u2}}{w_{r2}} = \mathrm{tg}\,\beta_2$$

$$c_{u2} = \Omega r_2 - c\,\mathrm{tg}\,\beta_2\, c_{r2}$$

$$gH + (e_2 - e_1) = (\Omega r_2)^2 - c\,\mathrm{tg}\,\beta_2 \frac{Q\,\Omega r_2}{2\pi r_2 b}$$

$$gH = \eta^{\pm 1}\left((\Omega r_2)^2 - c\,\mathrm{tg}\,\beta_2 \frac{Q\,\Omega r_2}{2\pi r_2 b}\right)$$

$\beta_1 < \beta_2$

η aerodynamisch, isentroper Wirkungsgrad

Spezialfall

$\rho_1 = \rho_2 = \rho$ homogene Dichte

statischer Dr. / piezometrischer Dr.

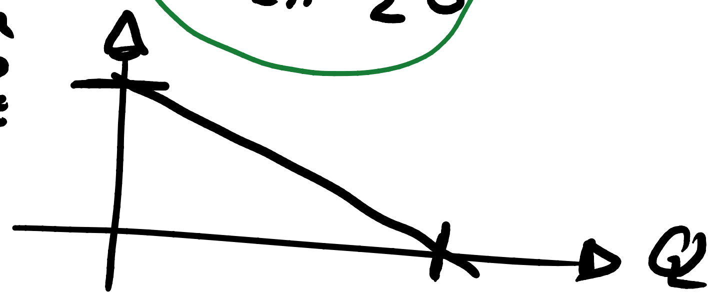
$$\rho g H = \Delta p_t = \left(p_2 + \rho \frac{c_2^2}{2} + \rho g z_2\right) - \left(p_1 - \rho \frac{c_1^2}{2} + \rho g z_1\right)$$

Totaldr.

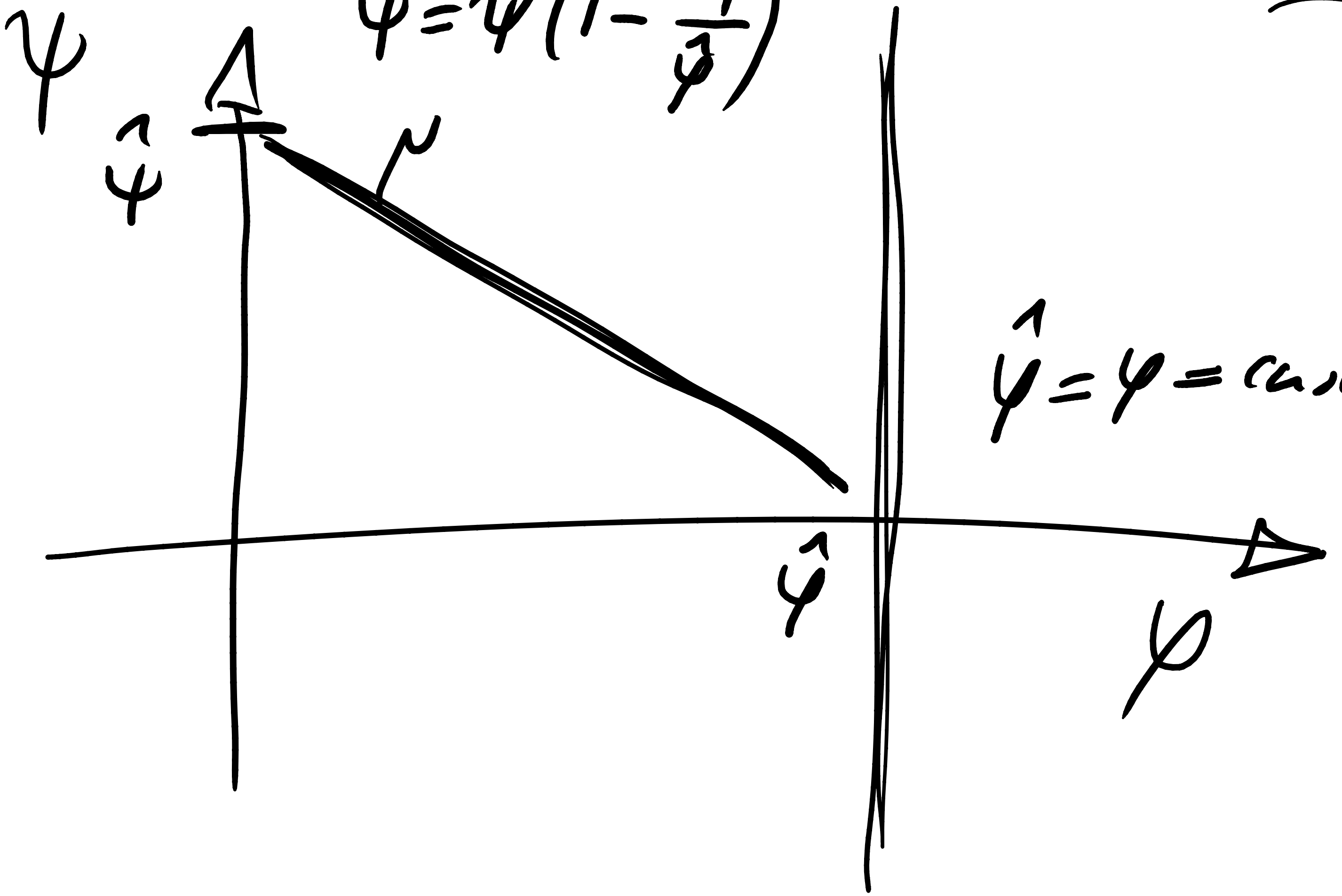
Druckziff. ψ · φ Durchflußziffer

$$\Delta p_t = \eta^{\pm 1}\left(\rho u_2^2 - \rho u_2 \frac{Q}{2\pi r_2 b} \cot \beta_2\right) \Bigg| \frac{1}{u_2^2}$$

$$\Delta \hat{p}_t \sim \rho u_2^2$$



$$\psi = \hat{\psi}\left(1 - \frac{\varphi}{\hat{\varphi}}\right)$$

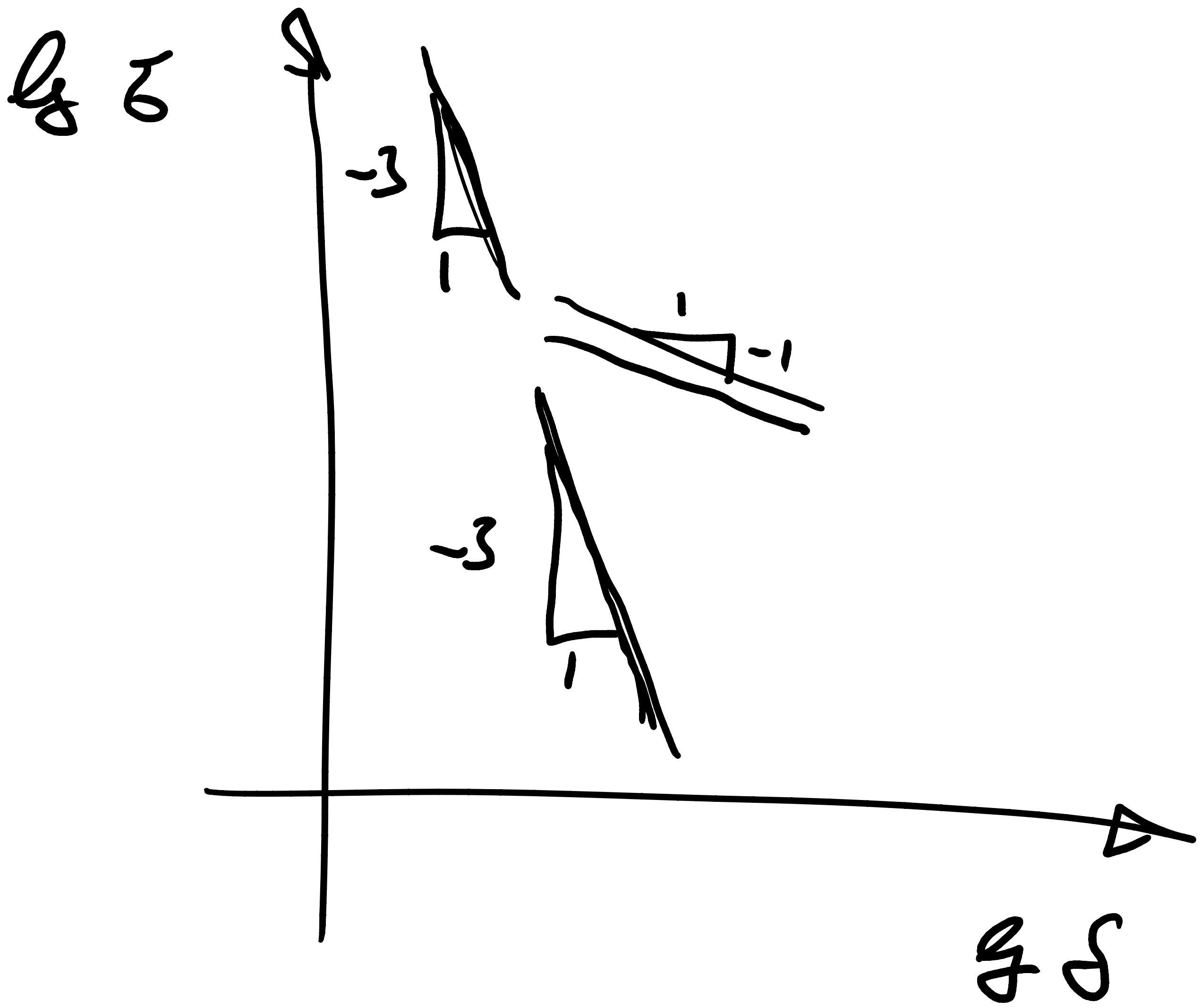


$$\hat{\varphi} = \varphi = \text{const}$$

Transformation $\Rightarrow$

$$(\psi, \varphi) \rightarrow (\sigma, \delta)$$

Cordier-diagramm.


lg ζ
-3
1
1
-1
-3
1
lg δ