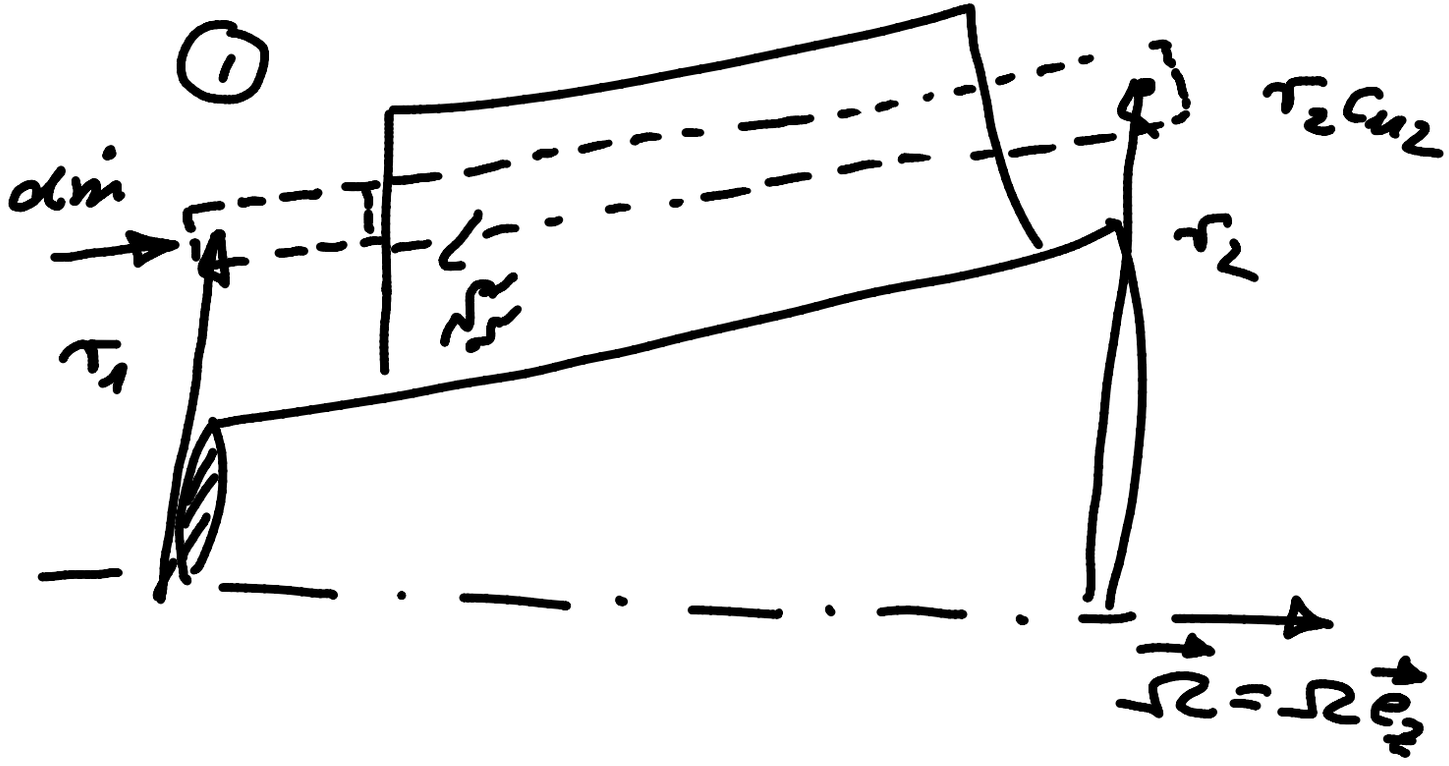
Eulersche Turbinengleichung

$$\frac{dM_{Sz}}{dm} = r_2 c_{u2} - r_1 c_{u1}$$

(2)

gilt für
für Turbinenstufen (T)
aber auch für
den Verdichter (V)



TECHNISCHE UNIVERSITÄT DARMSTADT
FLUID SYSTEM TECHNIK
Grundlagen der Turbomaschinen und Fluidsysteme

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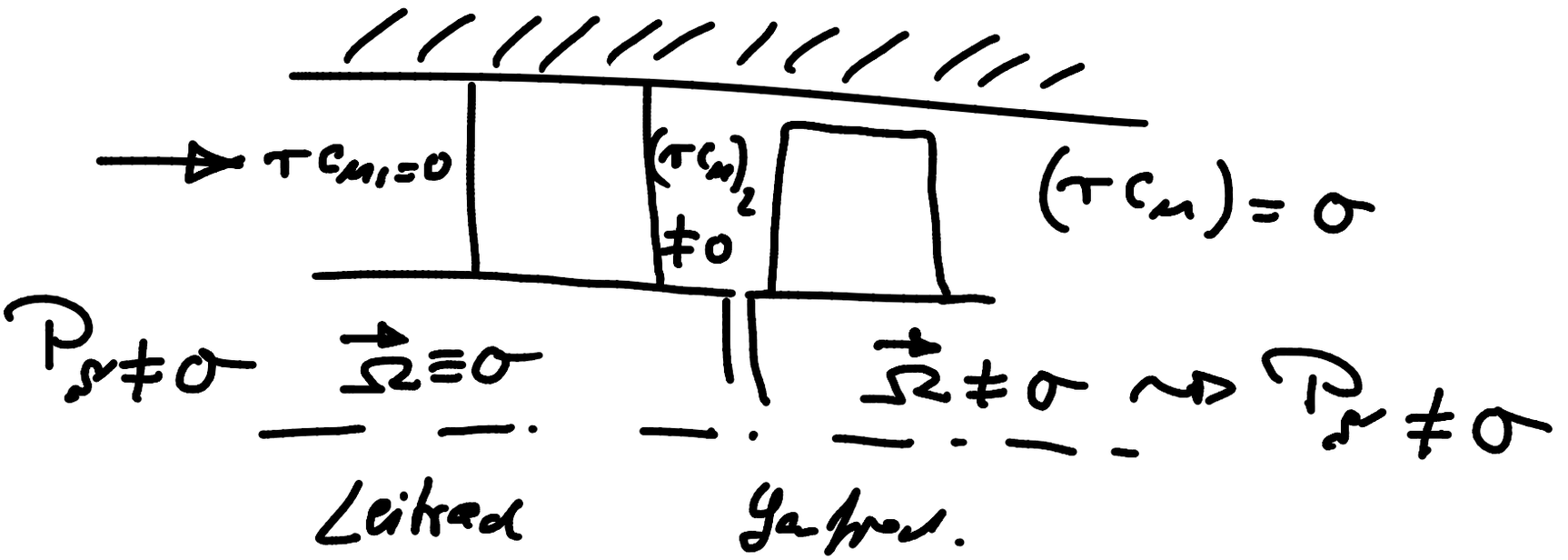
Vorlesung 16 F 93

Axiale Durchströmg.

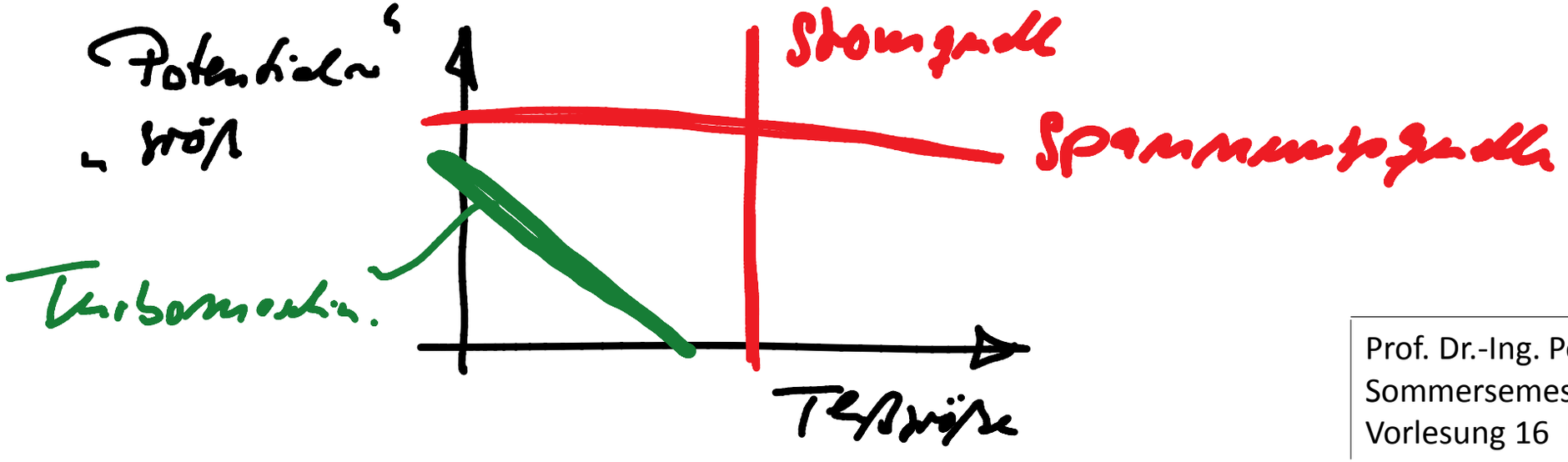


Eulersche Turbinengleichung $\cdot \vec{\Omega} =$

Energiegleichung $\rightsquigarrow$ Eulersche Hauptgleichung der Turbomaschinen.

Drehzahl = fkt (Volumenstrom)

$\hat{=}$ Potentialform $\hat{=}$ elektrischer Strom.



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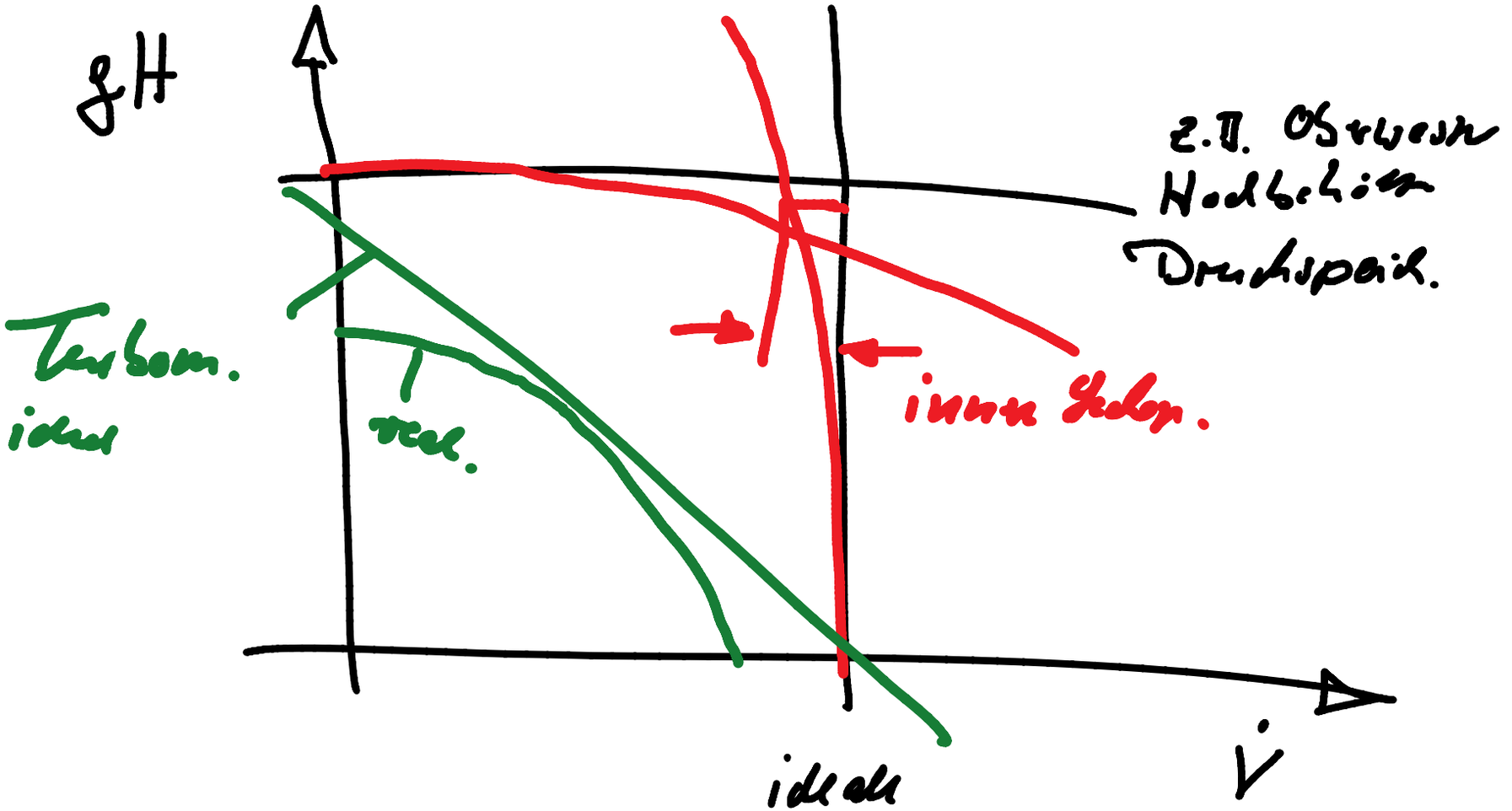
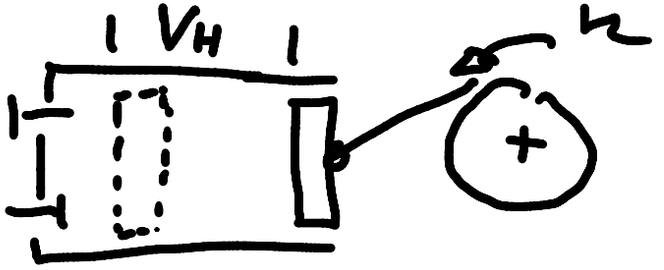


ideale Verdrängermaschine.

V_H Hubvolumen
Schluckvolumen
n Drehzahl
z Zahl der Arbeitsräume



$$\dot{V}_{theor.} = n V_H z$$

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1. Hauptsatz für $\dot{Q} \equiv 0$ (adiabat)

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

$$\frac{dP_s}{dm} = h_{t2} - h_{t1} = \frac{1}{\eta^{\pm 1}} \, gH$$

+1 Arbeitsmaschine
−1 Kraftmaschine.

$$gH := c_2' - c_1 = p_2 - p_1 + \psi_2 - \psi_1 + \frac{c_2^2}{2} + \frac{c_1^2}{2}$$

$$P = \int \frac{dp}{\rho}$$

2. Eulersche Turbinenhauptgleichung $\vec{\Omega} = \Omega \vec{e}_z$

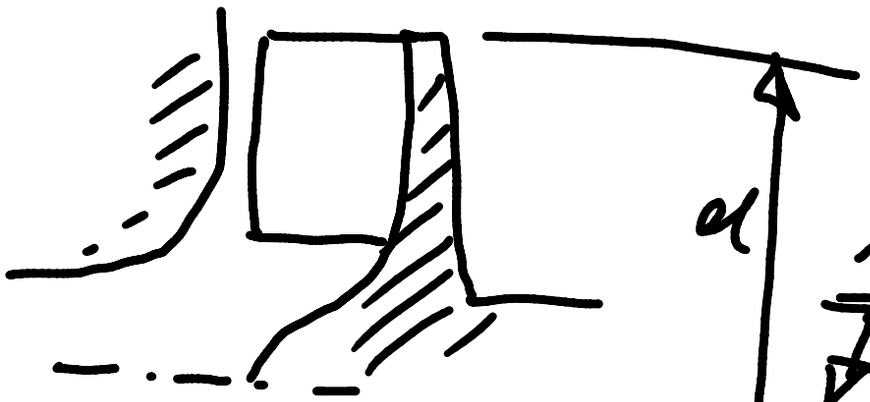
$$\frac{dM_z}{dm} \Omega = r_2 \Omega c_{u2} - r_1 \Omega c_{u1}$$

$$\frac{dP_{st}}{dm} = u_2 c_{u2} - u_1 c_{u1}$$

$$\underbrace{h_{t2} - h_{t1}}_{\text{energetische Größe}} = \underbrace{u_2 c_{u2} - u_1 c_{u1}}_{\text{rein kinematische Größe}}$$

mit $h_{t2} - h_{t1} = \frac{1}{\eta^{\pm 1}} g H$

$$g H = \eta^{\pm 1} \left(u_2 c_{u2} - u_1 c_{u1} \right) \quad \Big| \; \frac{1}{u_2^2/2}$$



$u_2 = \Omega r_2 = 2\pi n r_2 = \pi n d$

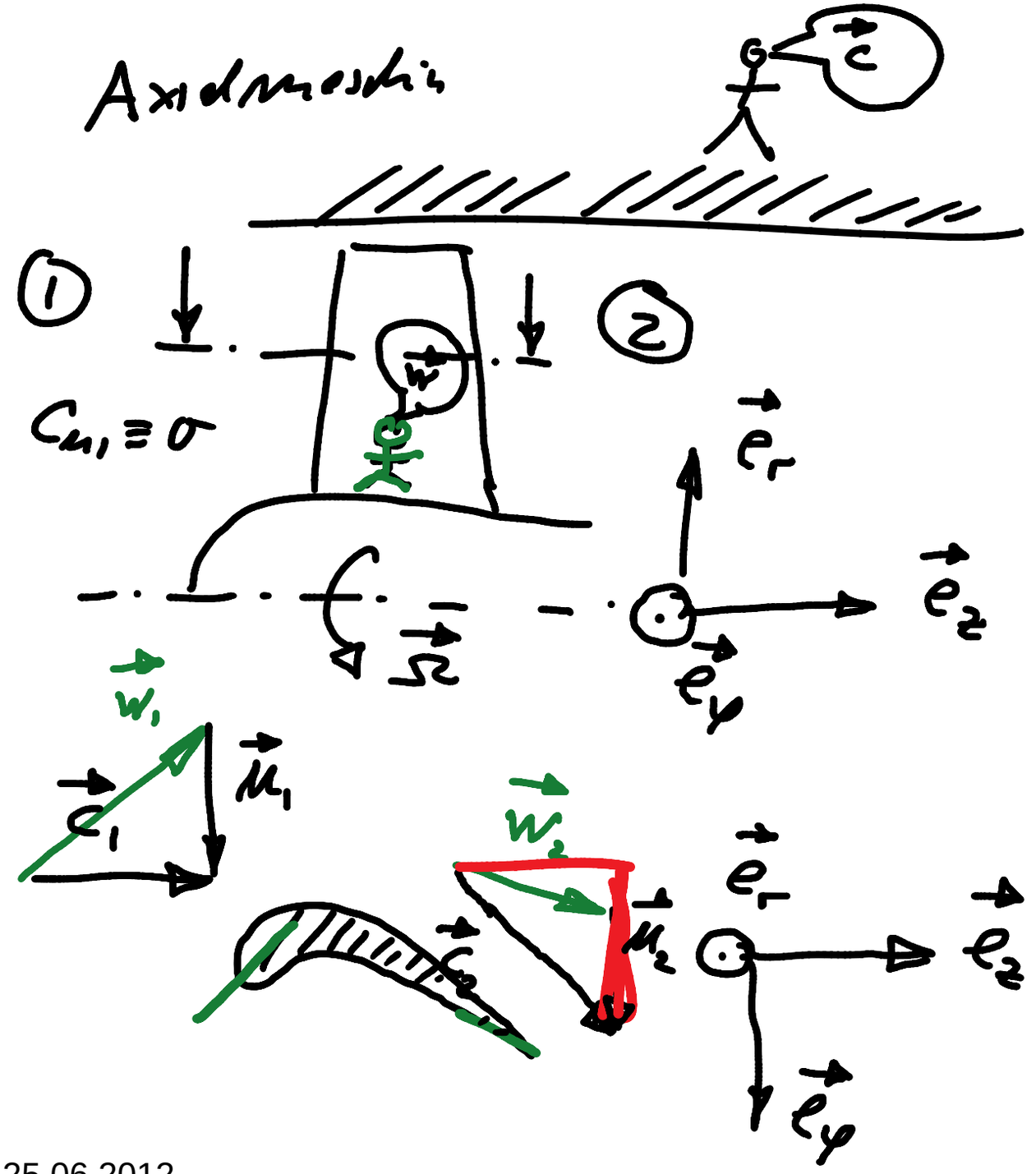
Wichtige Größe.

$$\frac{gH}{u_2^2/2} = z^{\pm 1}\left(2\frac{c_{u2}}{u_2} - 2\,\frac{r_1}{r_2}\,\frac{c_{u1}}{u_2}\right)$$

$:= \psi$ Druckziffer.

$\frac{c_{u1}}{u_2}$ Vordrall $\equiv 0$ für ein drallfreies Anström.

Axialmaschine



Geschwindigkeitsdreieck

$$\vec{c} = \vec{w} + \vec{u} + \vec{v}$$

$\vec{c}$ absolute Geschw.

$\vec{w}$ relative Geschw.

$\vec{u}$ Umfangsgeschw.

$\vec{v}$ Führungsgeschw. $= 0$ i.d.R.

$\frac{c_{u2}}{u_2}$

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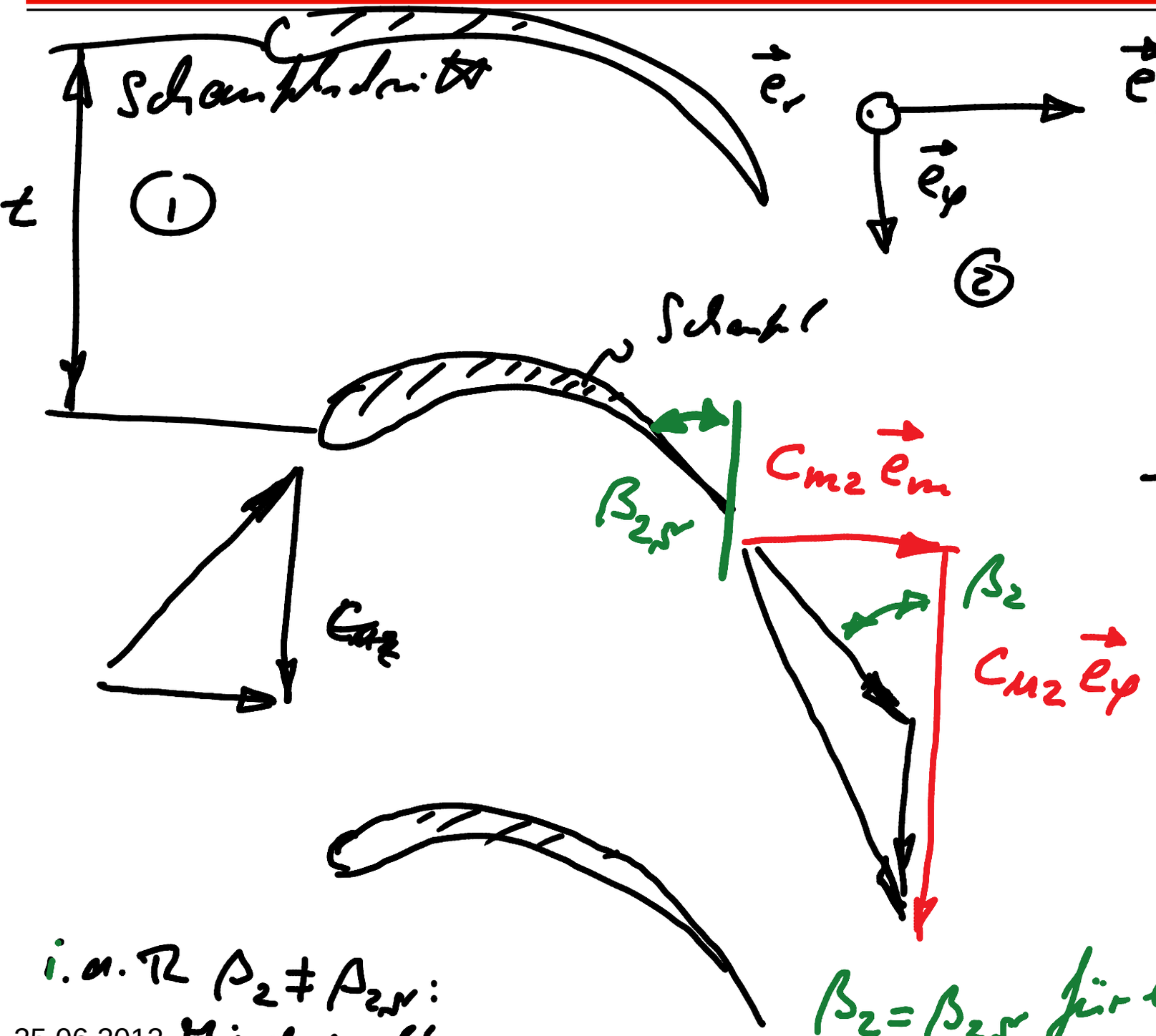


Gerades Schaufelgitter
Teilung t

„m" Meridianrichtung
m = z bei Axialmaschine
m = r bei Radialmaschine

i.a.R. $\beta_2 \neq \beta_{2sr}$:
Minderumlenkung

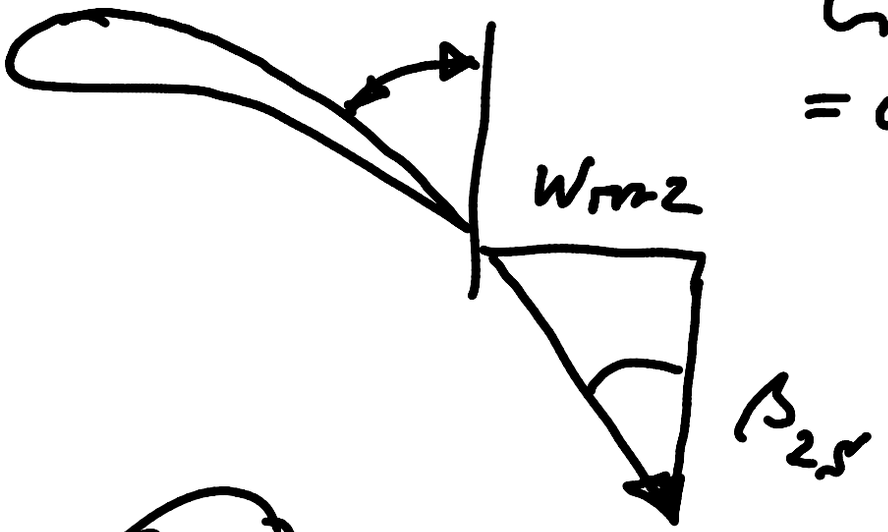
$\beta_2 = \beta_{2sr}$ für eine schaufellose Abs.

$$c_{u2} = \vec{c}_2 \cdot \vec{e}_\varphi = \left(\vec{w}_2 + \vec{u}_2\right) \cdot \vec{e}_\varphi$$

$$= w_{u2} + u_2$$

$$= \operatorname{ctg}\beta_{2s}\, w_{m2} + u_2 \quad \Big| \; \frac{1}{u_2}$$

$w_{m2} = c_{m2}$



$$\frac{c_{u2}}{u_2} = \frac{c_{m2}}{u_2} \operatorname{ctg}\beta_{2s} + 1$$

φ Durchflußzahl

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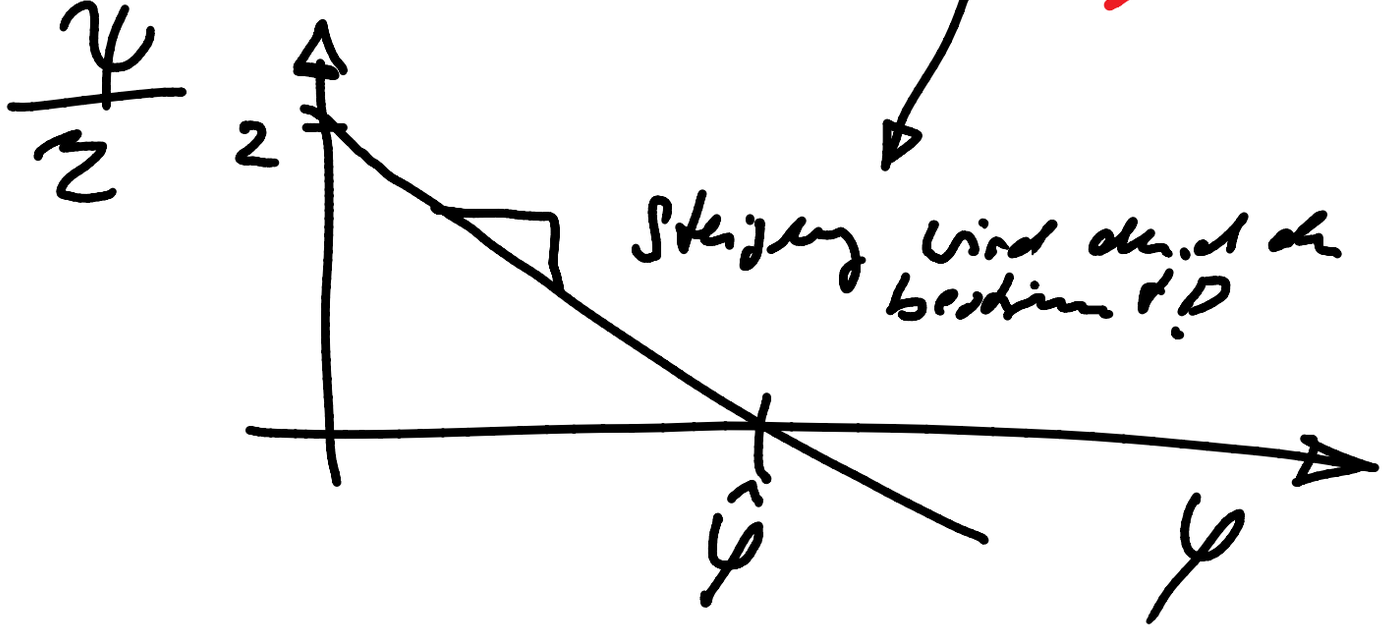
Einsetzen in die Umfangsgl.:

$$\psi = 2z^{\pm 1}\left(-\varphi \operatorname{ctg}\beta_2 + 1\right).$$

$$= 2z^{\pm 1}\left(1 - \varphi \operatorname{ctg}\beta_2\right)$$

$$\frac{\psi}{z^{\pm 1}} = \psi_{th\infty} = 2\left(1 - \varphi \operatorname{ctg}\beta_2\right)$$

ideale Endlaufzahl



Steigung wird allein durch Schaufelwinkel bestimmt!

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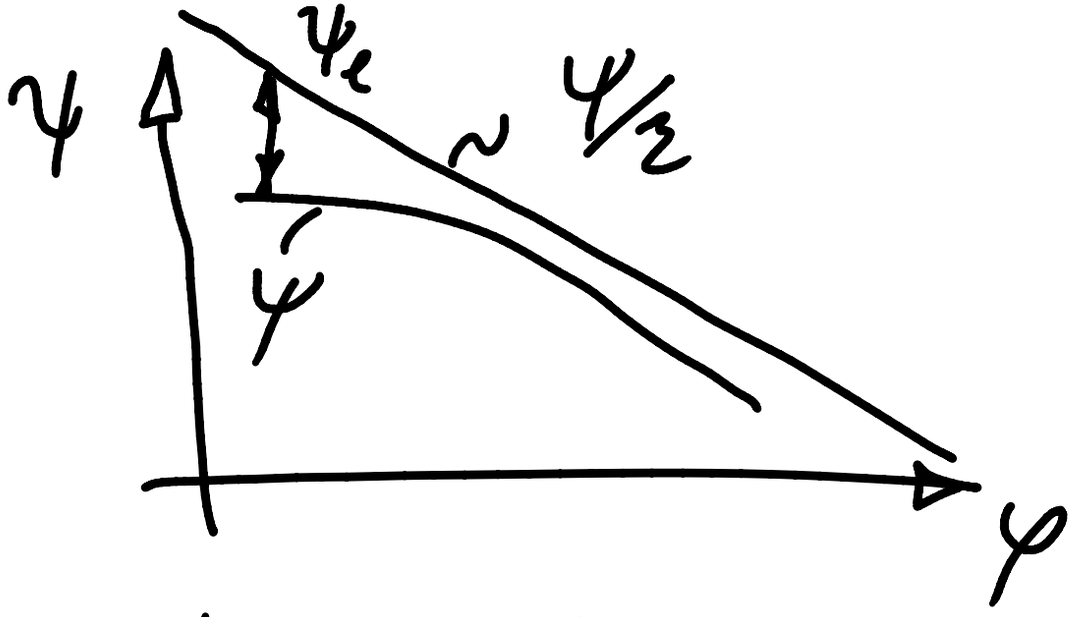
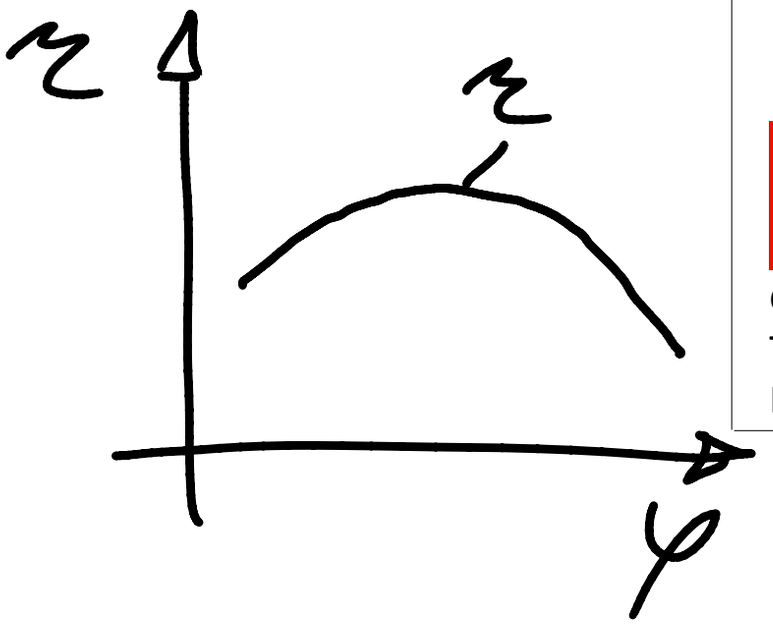
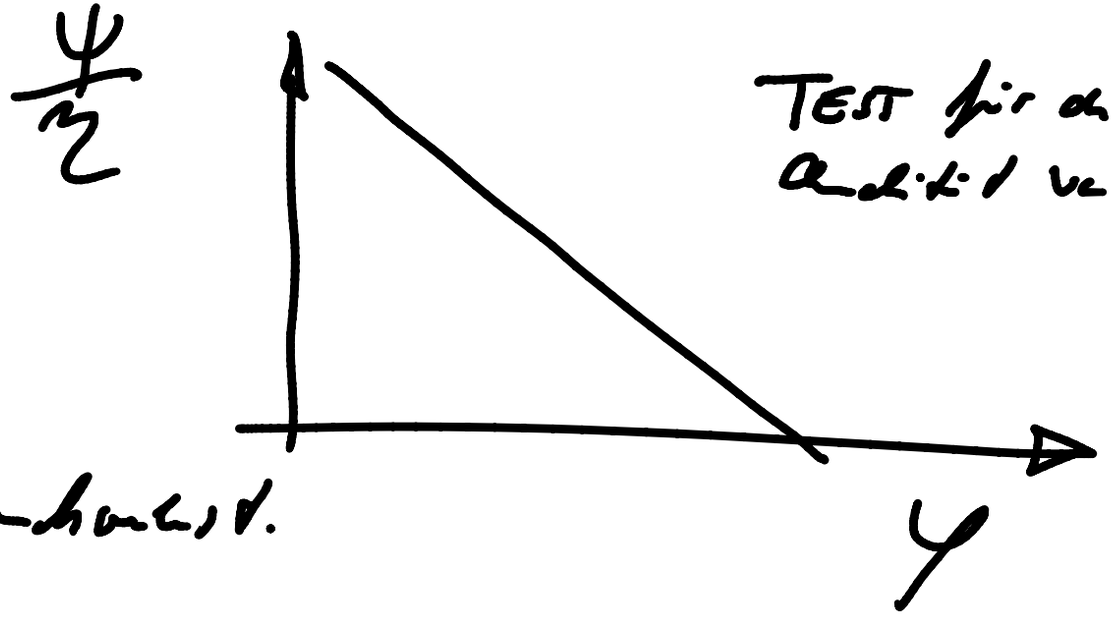




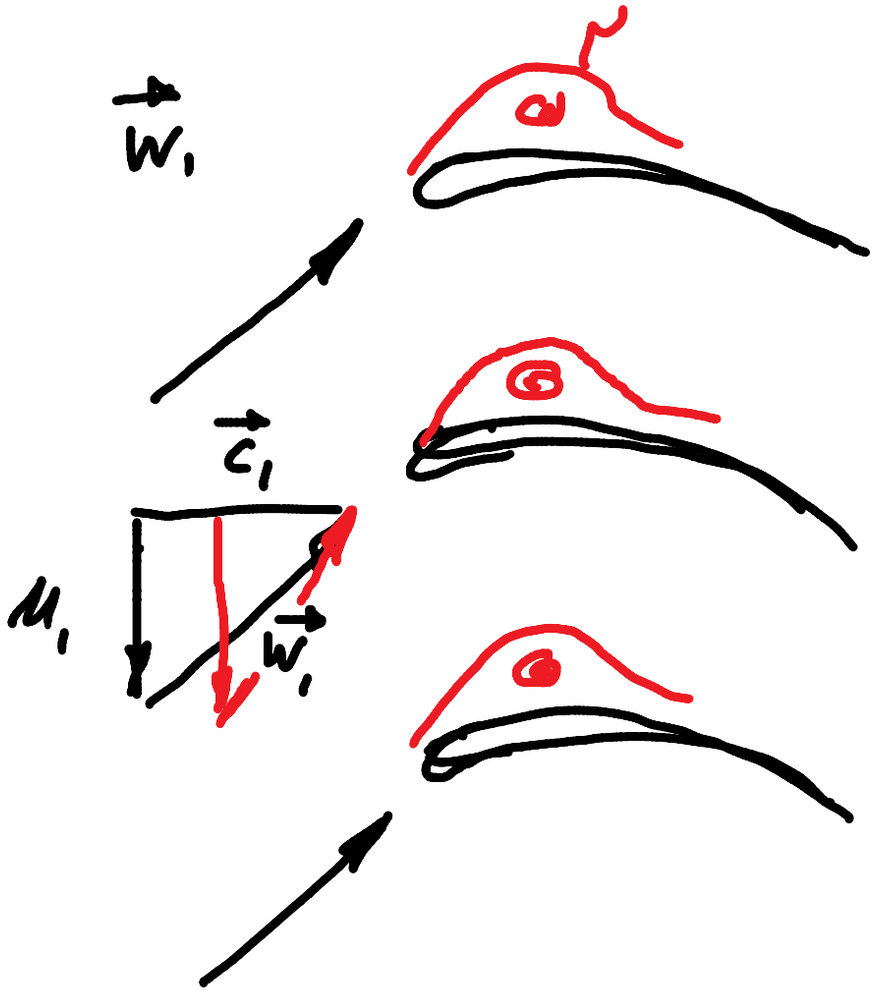


TEST für die Qualität der Rechnung

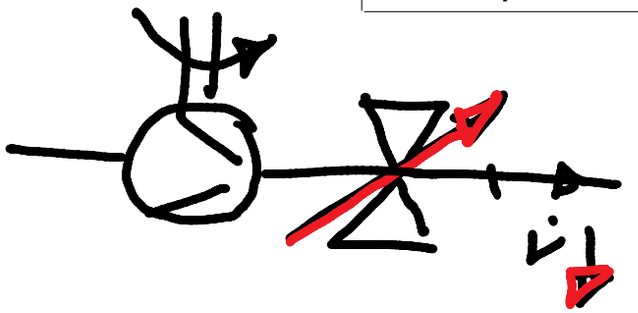
ψ_t immer Durchmesser.

Wohin kommt der Strahl?

Teilstrahlen.



$h = const$



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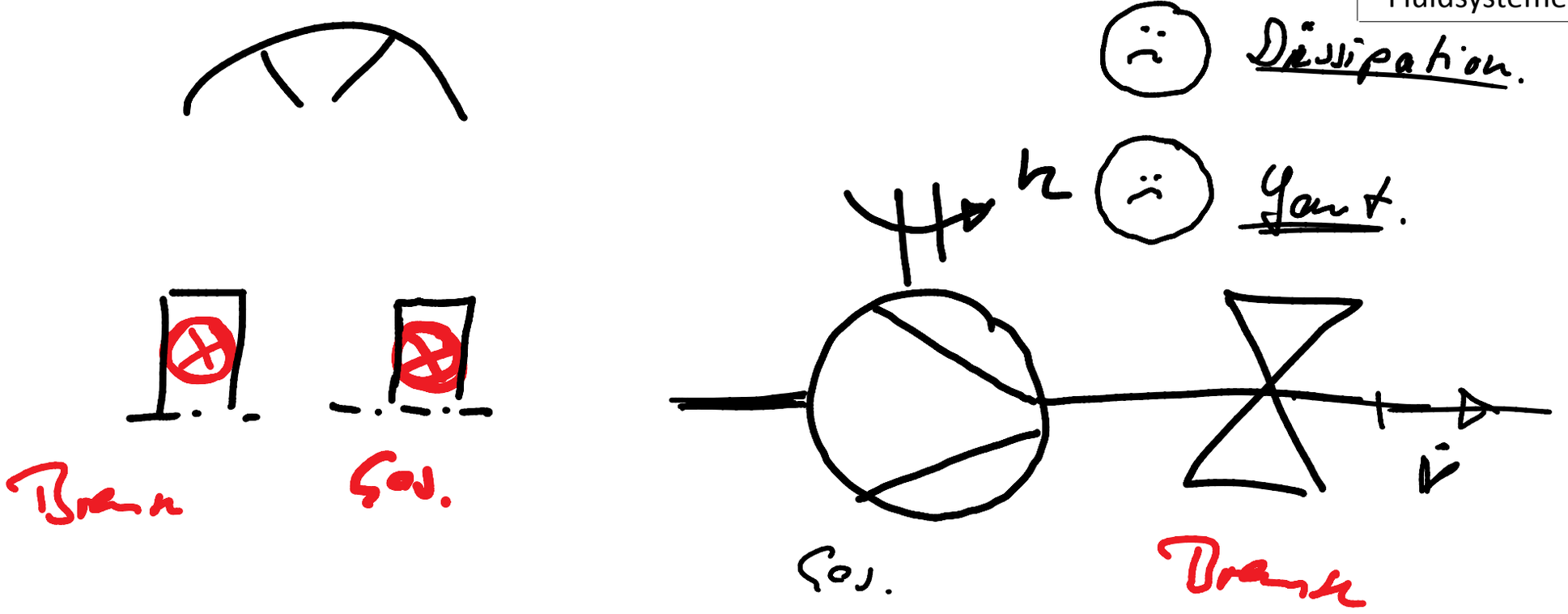
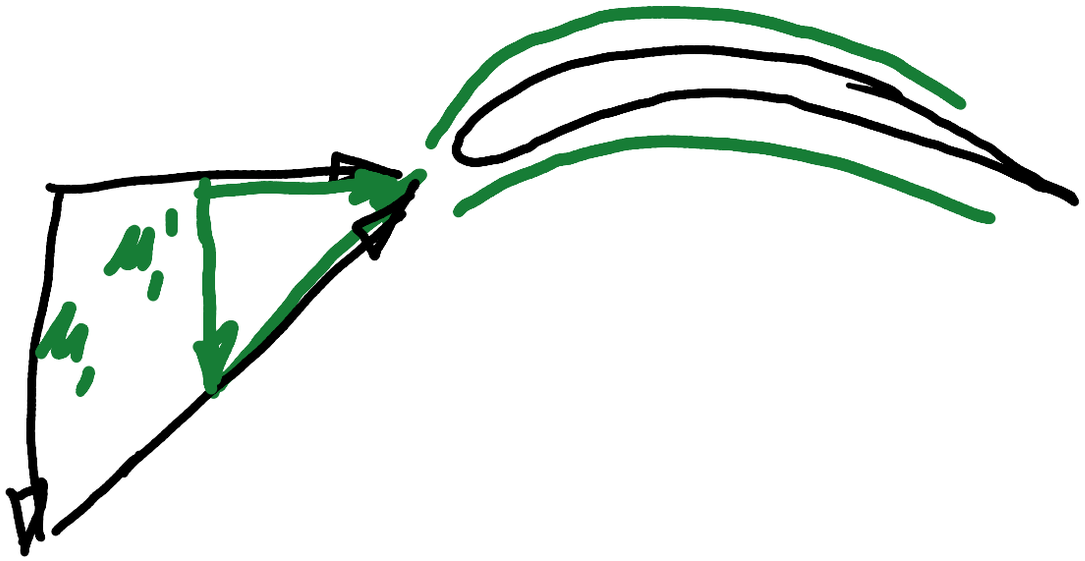
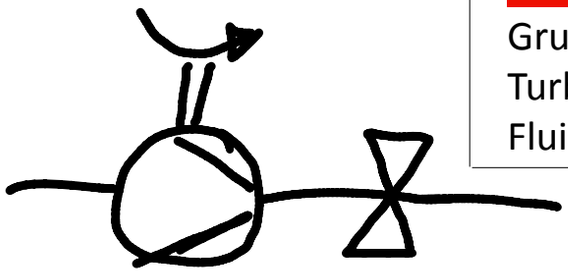
Der Arbeitsplan.





$u_1 \rightarrow u_1' < u_1$



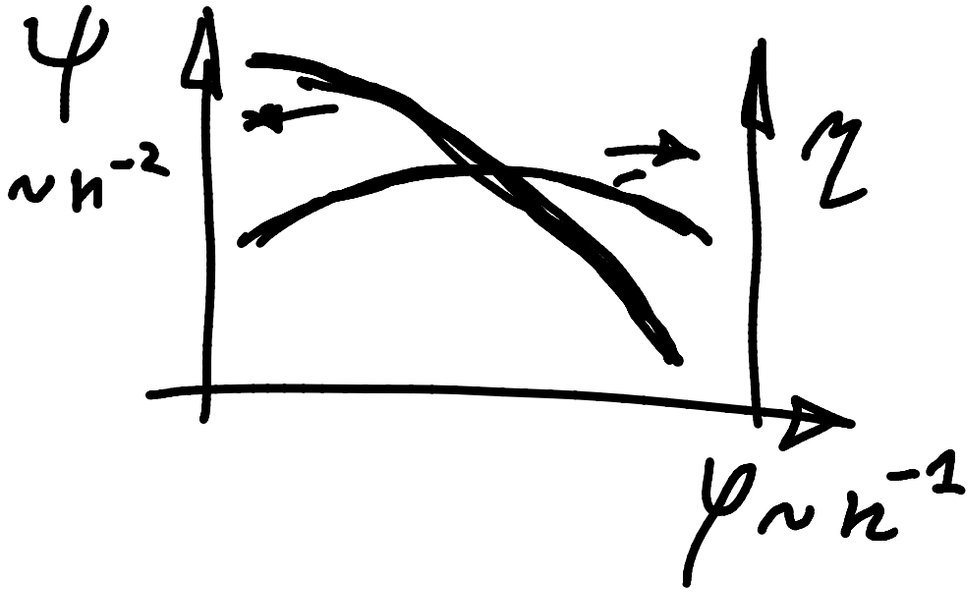
Drehzahlregelung !

$u_1' < u_1$

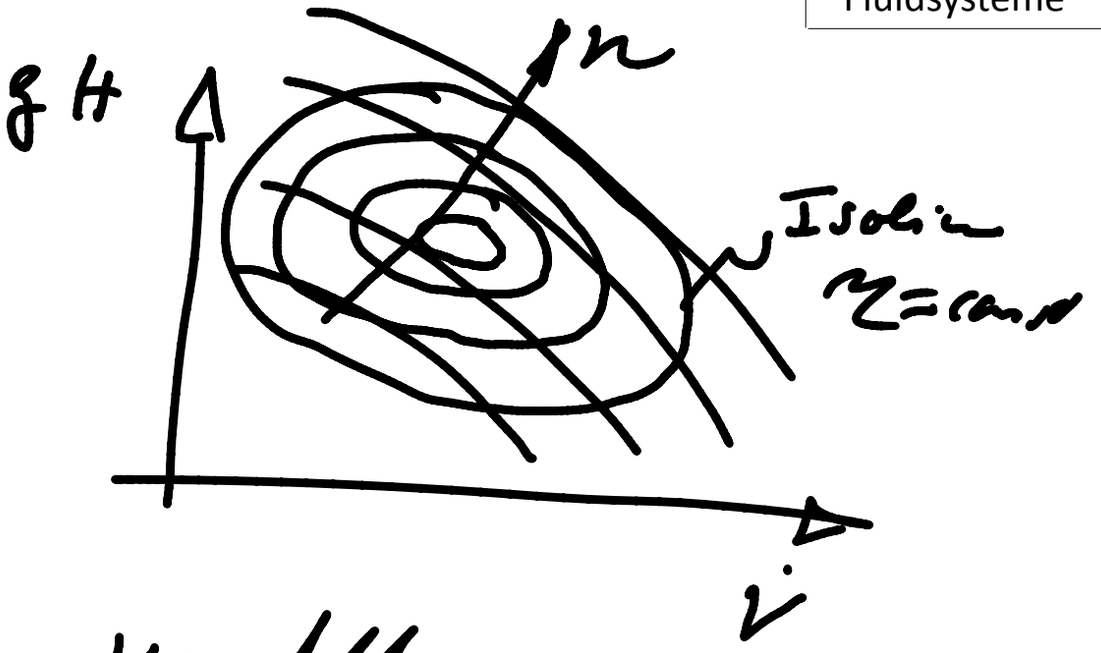
Frequenzumrichter → Motor → Pumpe.

$$\psi := \frac{gH}{u_2^2/2} = \frac{gH}{n^2 d^2 \pi^2/2}$$

$$\varphi := \frac{c_{m2}}{u_2} = \frac{\dot{V}}{A_2 \pi n d}$$



Kennlinie



Kennfeld

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