Cordierdiagramm

$$n = n(gH, \dot{V}, \nu, \ldots)$$

$$d = d(gH, \dot{V}, \nu, \ldots)$$

Durchmesserzahl

$$\delta \sim d$$

$$\delta = \frac{\sqrt{\pi}}{2}(2gH)^{\frac{1}{4}} \dot{V}^{-\frac{1}{2}} d$$

Schnelllaufzahl

$$\sigma \sim n$$

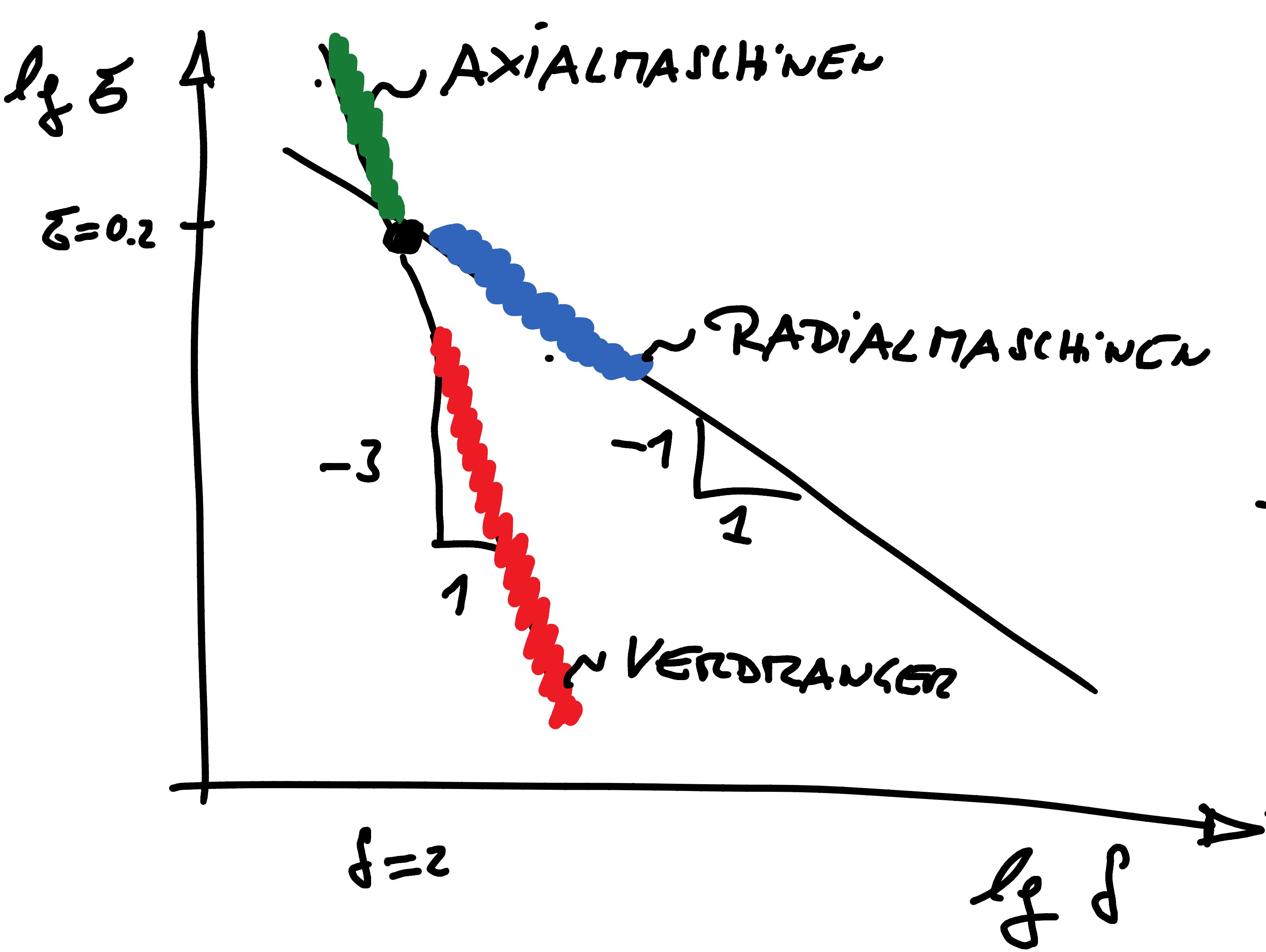
$$\sigma = 2\sqrt{\pi}(2gH)^{-\frac{3}{4}} \dot{V}^{\frac{1}{2}} n$$

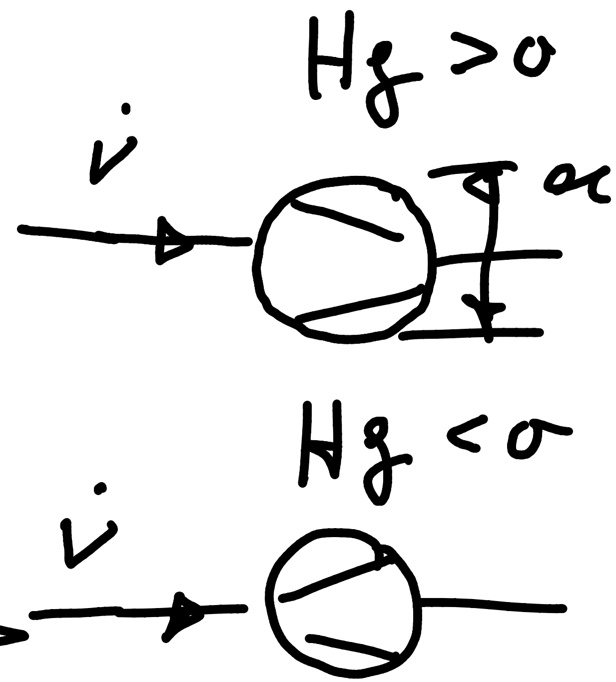
$$\Longleftrightarrow$$

$$\delta = \delta(\sigma, Re, Ma, Fr, \text{Gestalt})$$

$$\eta = \eta(\sigma, Re, Ma, Fr, \text{Gestalt})$$

TYP — MASCHINENGRÖßE — QUALITÄT.

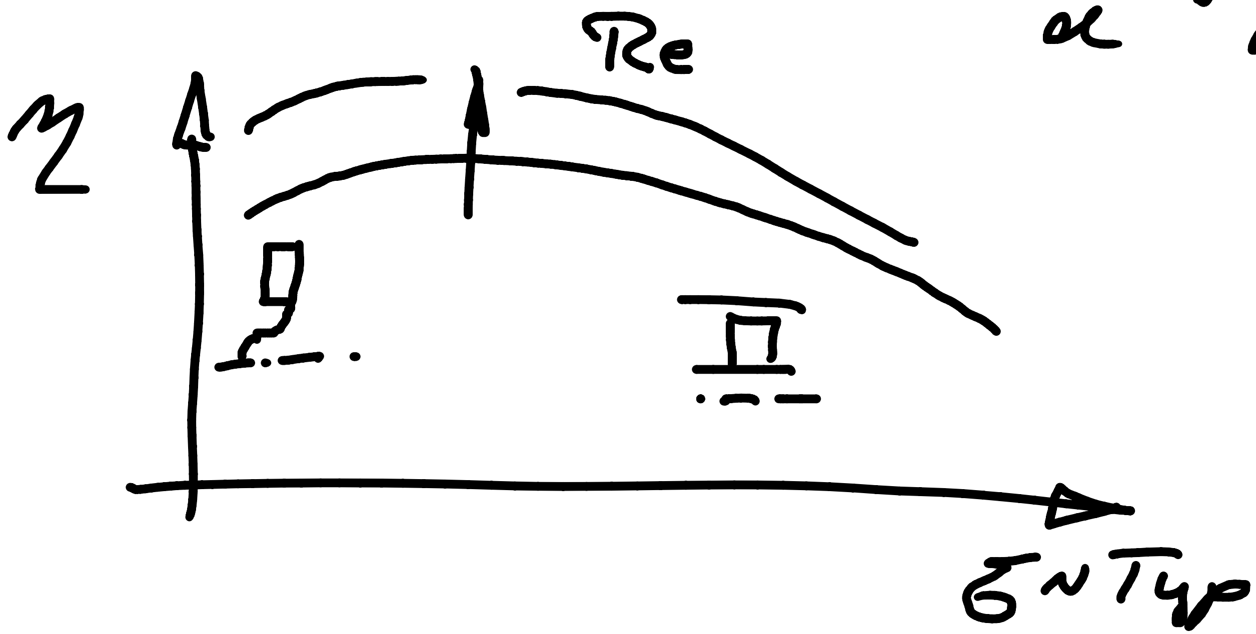

lg ζ
ζ=0.2
AXIALMASCHINEN
RADIALMASCHINEN
VERDRÄNGER
-3
1
-1
1
δ=2
lg δ


Hg > 0
V̇
α
Hg < 0
V̇

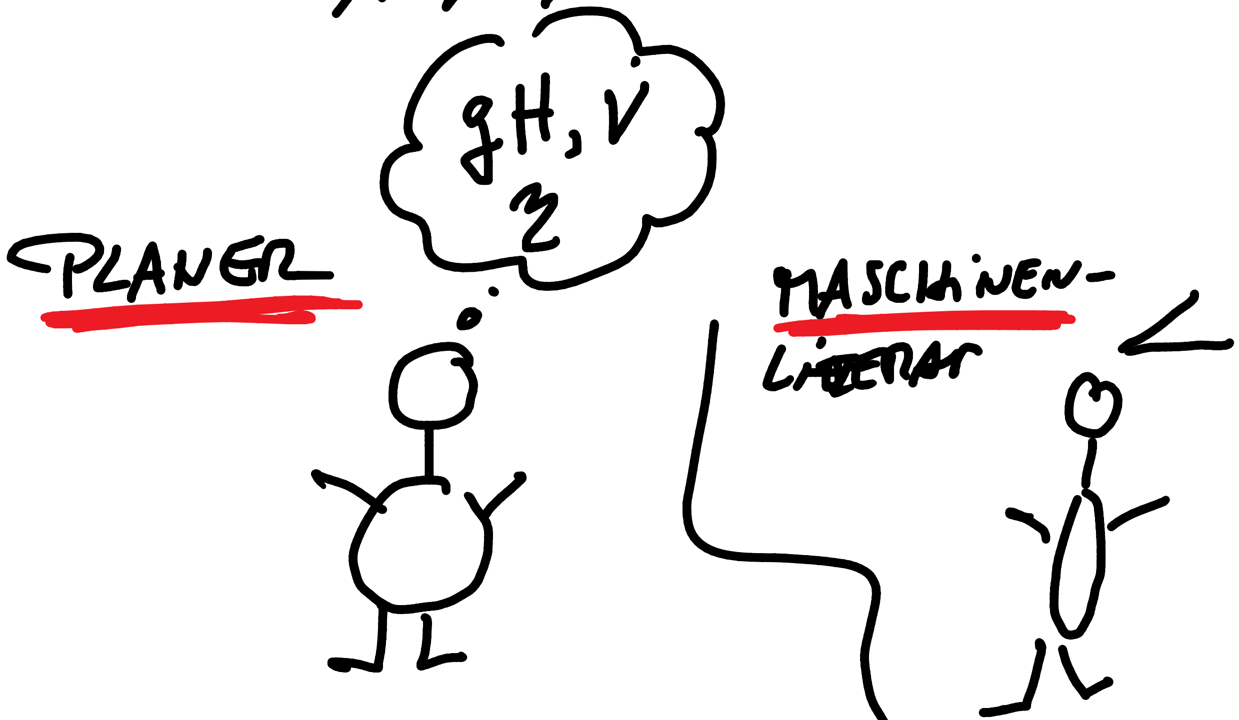
$$\delta = \delta(\sigma, \text{Größe}, \text{Qualität})$$

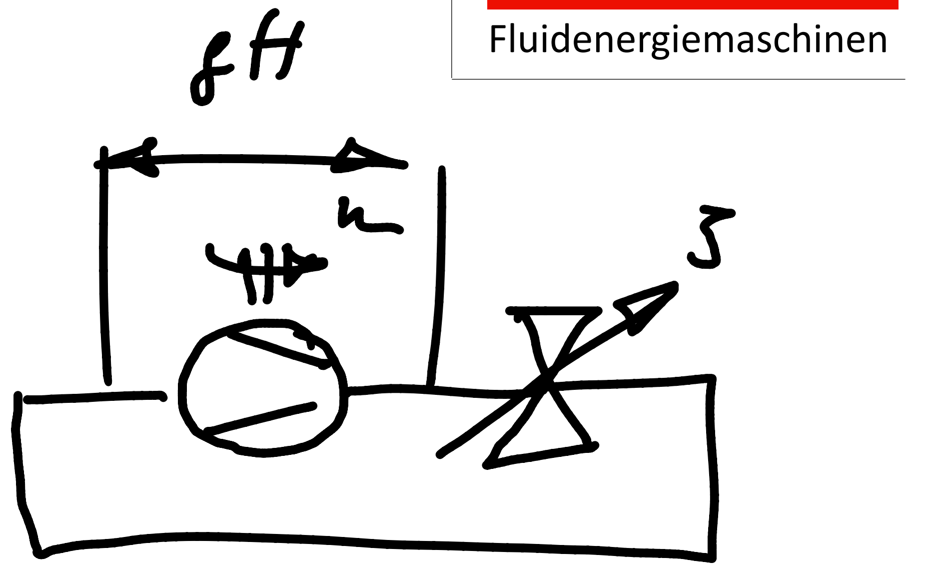
$$\eta = \eta(\text{Typ}, \text{Größe}, \text{Qualität})$$

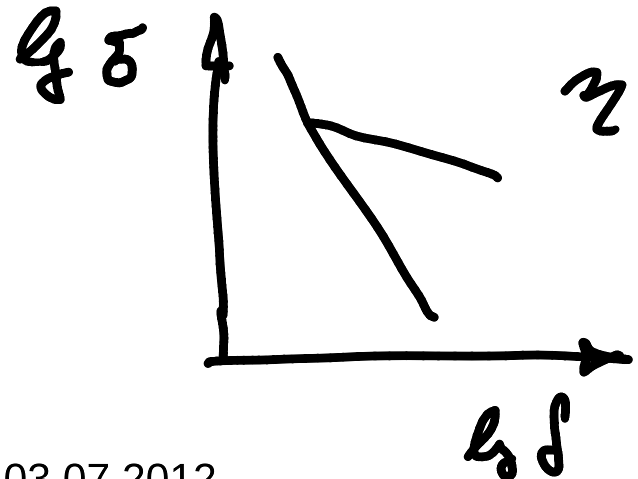
$$\sigma \qquad Re \qquad \frac{k}{d}, \frac{s}{d}$$

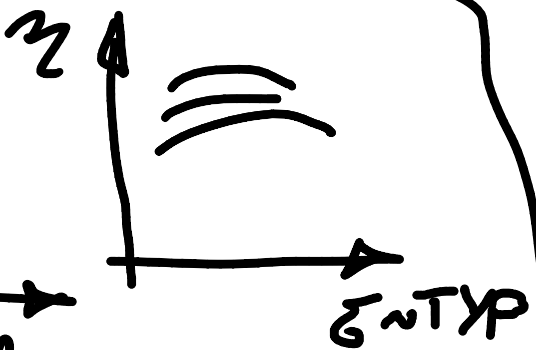


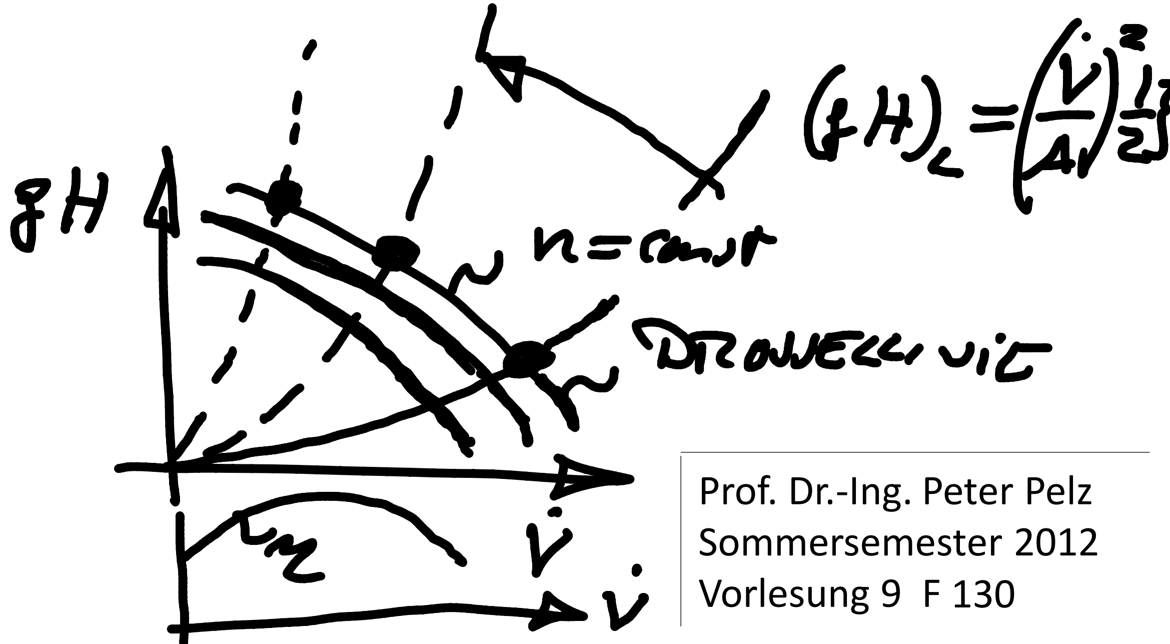
Frage: Woher kommen die Asymptote im Cordier-Diagramm.











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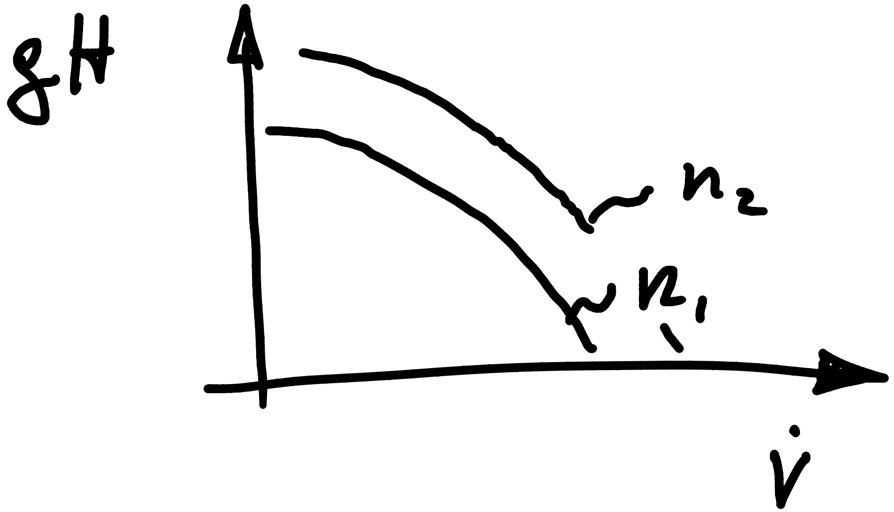
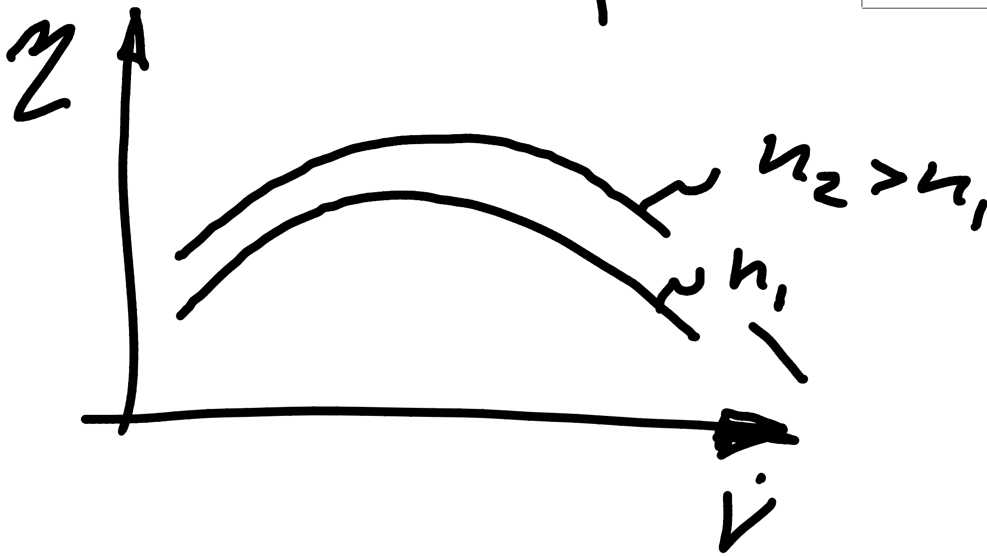
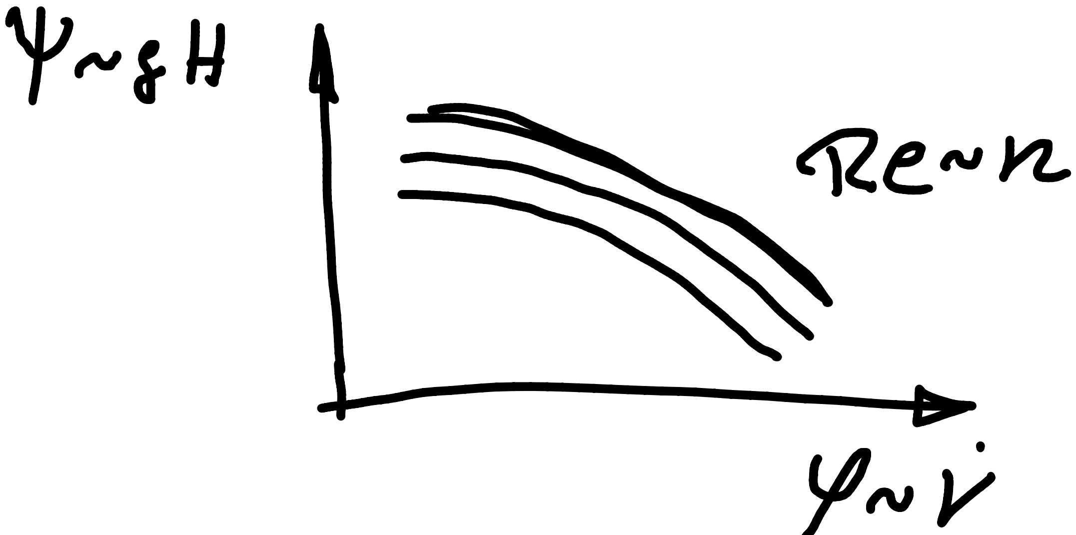
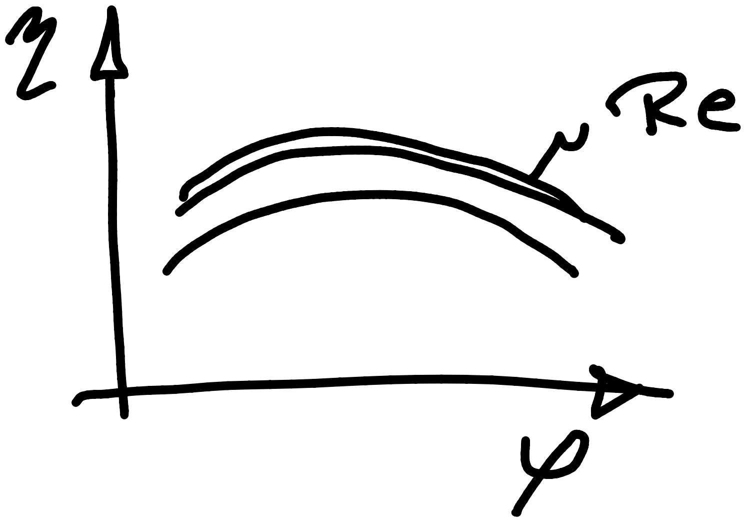
Kennlinie der Maschine:
Maschinenkennfeld









Durchflußziffer $$\varphi := \frac{1}{\delta^3 \sigma} = \frac{\dot{V}}{n d^3} \text{ const.}$$

Druckziffer $$\psi := \frac{1}{\delta^2 \sigma^2} = \frac{gH}{n^2 d^2} \text{ const.}$$

$$\underbrace{(\varphi, \psi)}_{\text{Maschinenkennzahl}} \xleftrightarrow{\text{Transformation}} (\sigma, \delta)$$

Auslegeplan.

Grund:

Dimensionsanalyse ist nicht eindeutig!

$$gH = gH(\dot V, n, d, \nu, a, \dots)$$

$$\eta = \eta(\dot V, n, d, \nu, a, \dots)$$

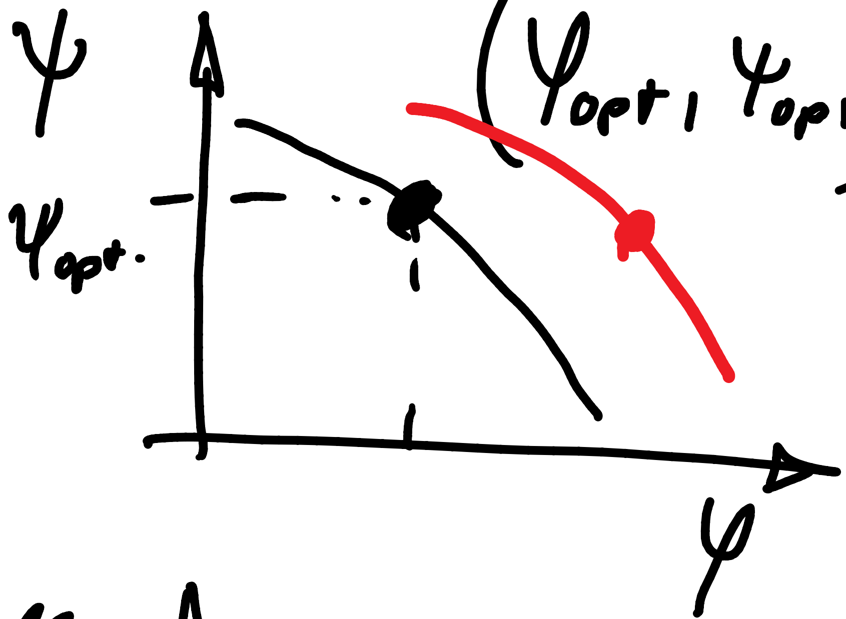
$$\psi = \psi(\varphi, Re, Ma)$$

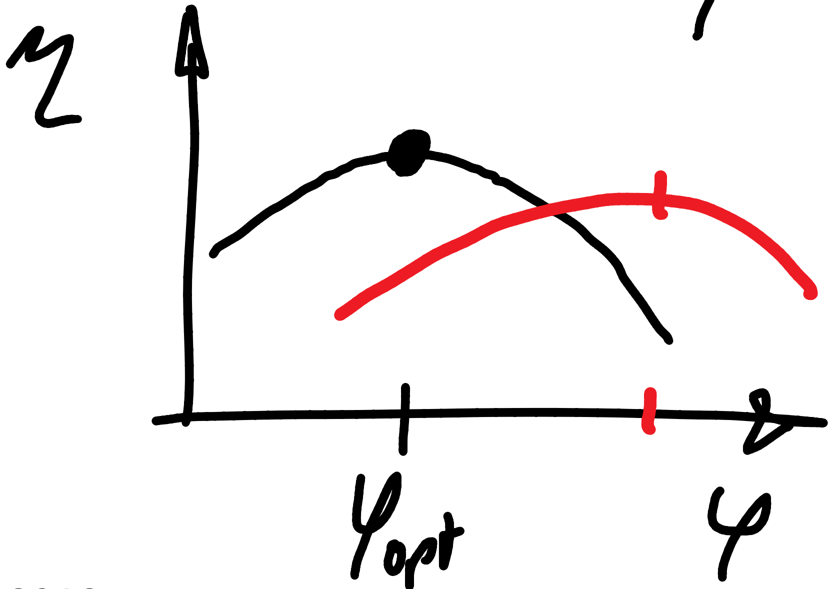
	gH	$\dot V$	n	d	ν	a
L	2	3		1	2	1
T	-2	1	-1		-1	-1

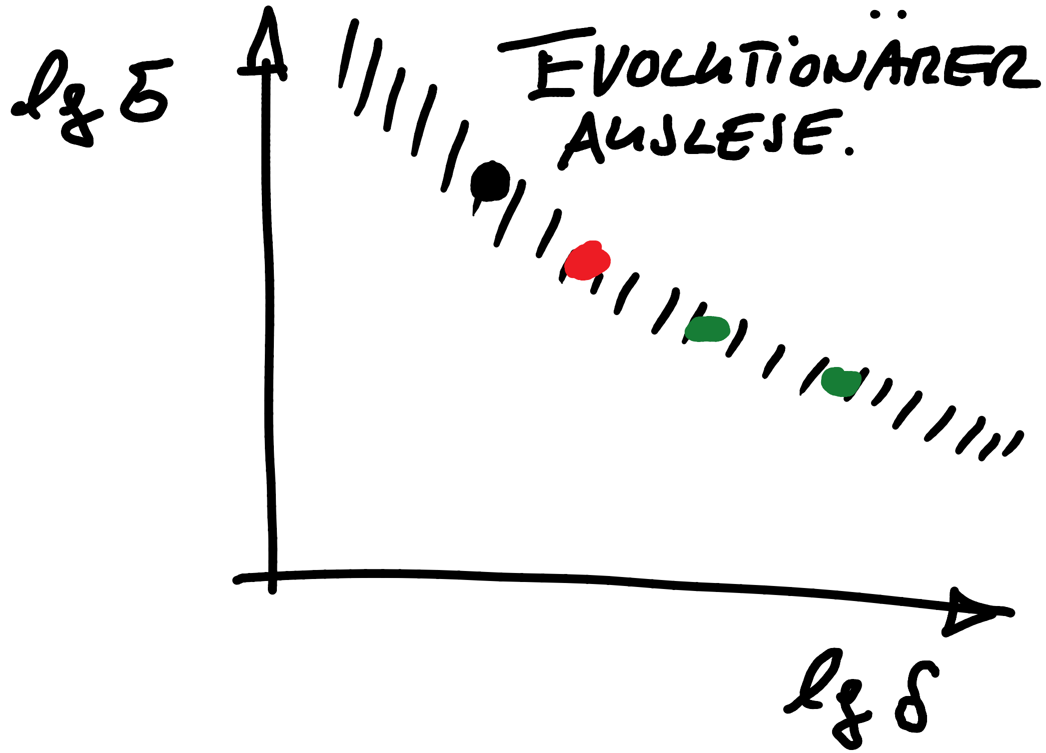
	$\frac{gH}{n^2 d^2} = \psi$	$\frac{\dot V}{n d^3} = \varphi$	n	d	$\frac{n d^2}{\nu} = Re$	$\frac{n d}{a} = Ma$
L	0	0		1	0	0
T	0	0	-1		0	0

Wichtig Eine Beschränkung auf den Bestpunkt wie von Cordier 1953 gemacht ist nicht notwendig!

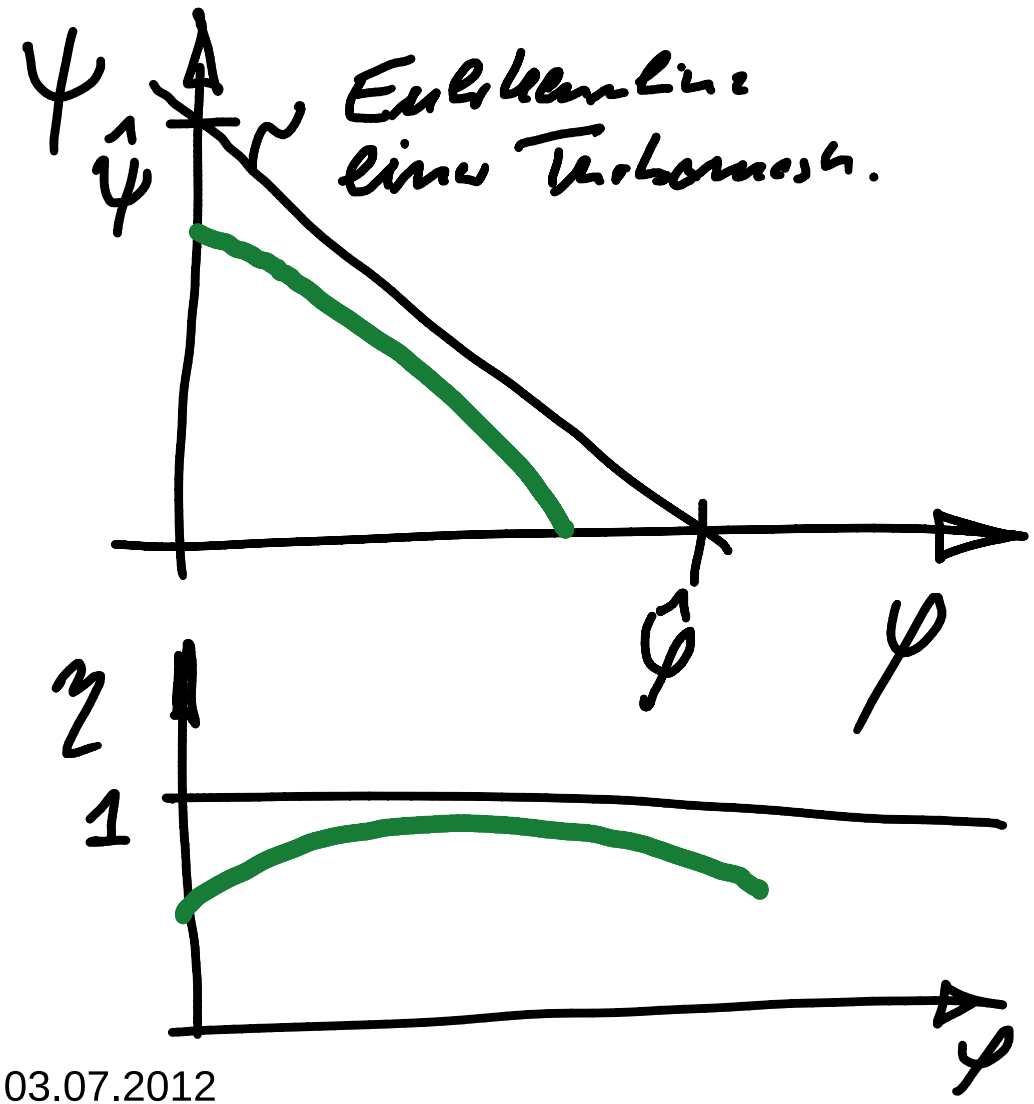
$$(\varphi_{opt}, \psi_{opt}) \rightarrow (\sigma_{opt}, \delta_{opt})$$

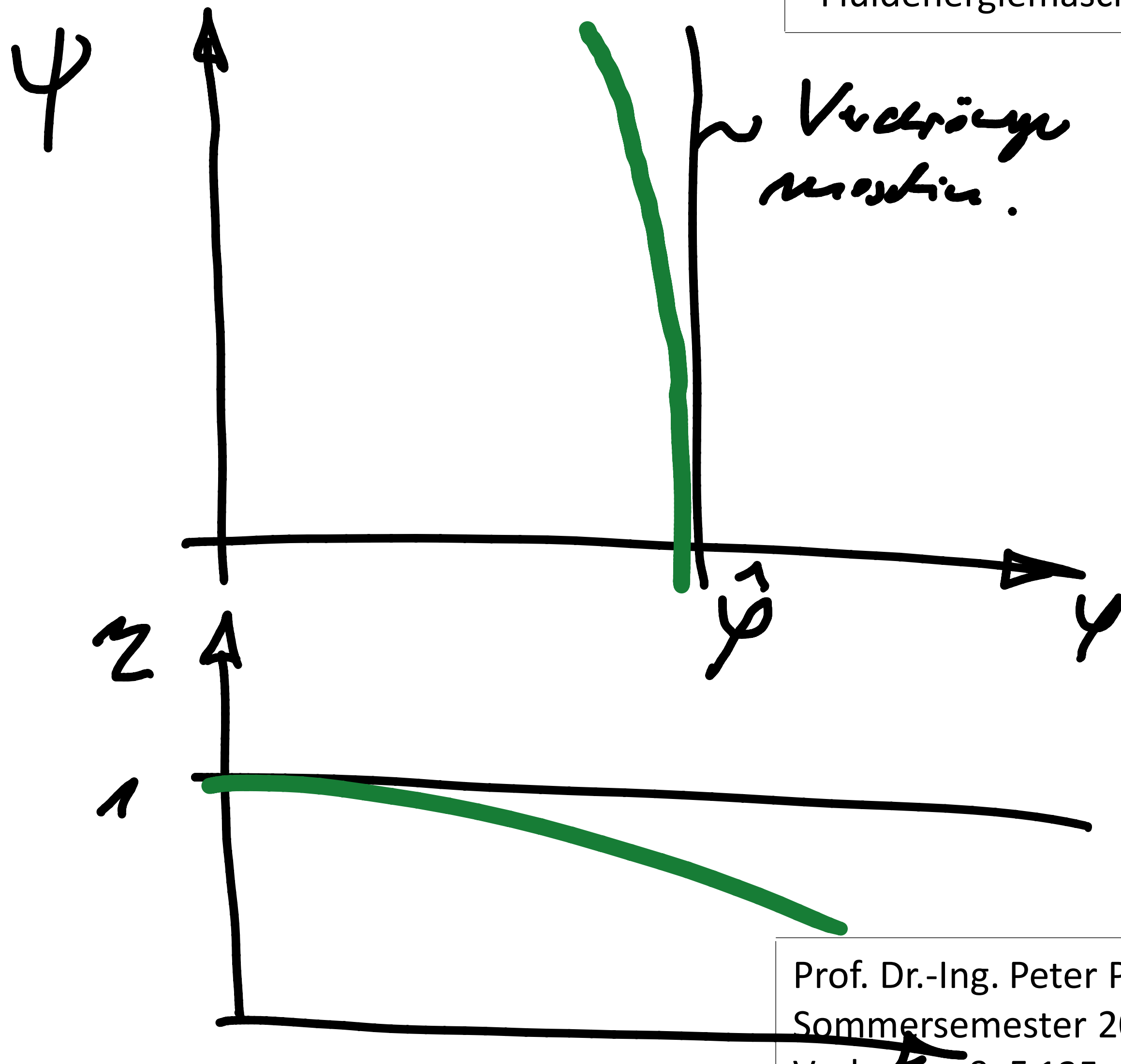






Transformation idealer Maschinenkennlinien in das Cordierdiagramm





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FLUID SYSTEM TECHNIK

Fluidenergiemaschinen

Turbomaschine

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

- Kraftmaschine

+ Arbeitsmaschine.

Verdrängermaschine

$$\varphi = \hat{\varphi} z$$

Transformation in das Cordier Diagramm mit

$$\varphi = \frac{1}{\delta^3 \sigma}, \quad \psi = \frac{1}{\delta^2 \sigma^2}$$

Turbomaschine | **Verdrängermaschine**

$$0 = \sigma^2 - \frac{\sigma}{\hat{\varphi}\,\delta^3} - \frac{1}{\hat{\varphi}\,\eta^{\mp 1}\,\delta^2} \qquad \sigma = \frac{\delta^{-3}}{\hat{\varphi}\,\eta}$$

Axialmaschine

„leicht mehr Volumenstrom“

$$\frac{\sigma}{\hat{\varphi}\,\delta^3} \;\gg\; (\ll)\; \frac{1}{\hat{\varphi}\,\eta^{\mp 1}\,\delta^2}$$

$$\leadsto \quad \delta = \frac{1}{\hat{\varphi}}\,\sigma^{-3}$$

Radialmaschine

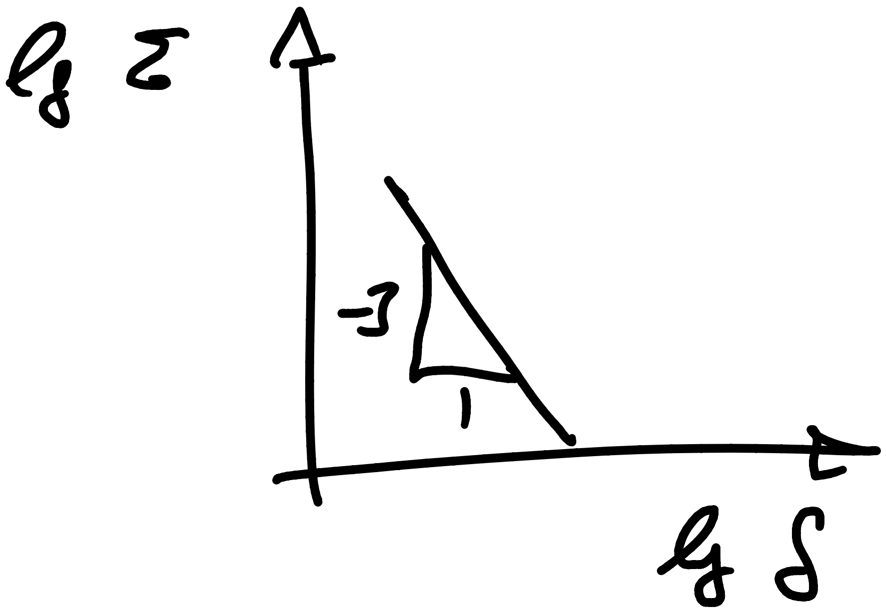
„leicht mehr Druck“

$$\delta = \frac{1}{\sqrt{\eta^{\mp 1}\hat{\varphi}}}\,\sigma^{-1}$$

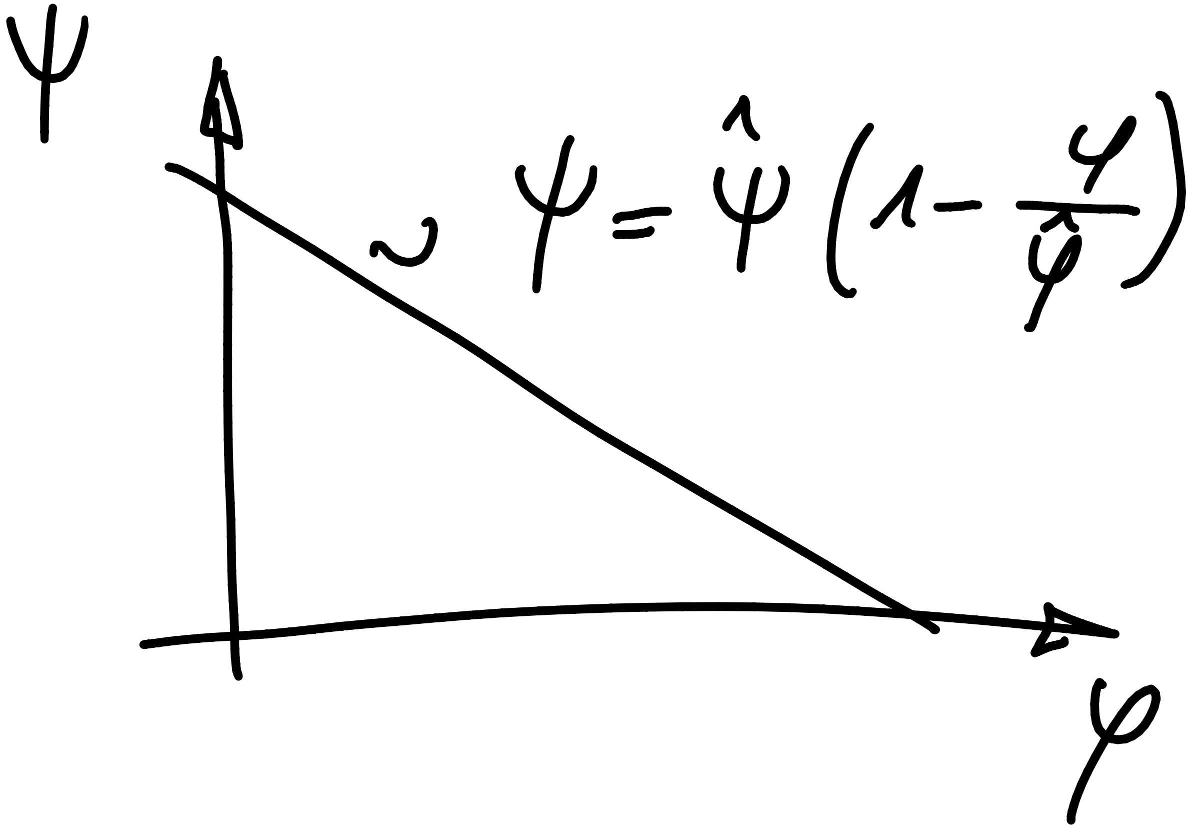
$$\cancel{\delta = \frac{1}{\eta\,\hat{\varphi}}\,\sigma^{-3}}$$

$$\psi = 2\hat{\varphi}$$

$$\frac{1}{\delta^{3}\sigma} = 2\hat{\varphi}$$



$$\sigma = \delta^{-3}\frac{1}{2\hat{\varphi}}$$



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

Eulerkennlinie

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Fluidenergiemaschinen

TECHNISCHE UNIVERSITÄT DARMSTADT

FLUID SYSTEM TECHNIK

Fluidenergiemaschinen

Energiegleichung = Drallsatz $* \Omega$.

$\frac{\partial}{\partial t} = 0, \quad \dot{Q} = 0$

$\Omega \frac{dM_z}{d\dot{m}} = \left(r_2 c_{u2} - r_1 c_{u1}\right)\Omega$

$h_{t2} - h_{t1} = \frac{dP_s}{d\dot{m}} \Longleftrightarrow \frac{dP_s}{d\dot{m}} = u_2 c_{u2} - u_1 c_{u1}$

$gH = \frac{dP_s}{d\dot{m}} \eta^{\pm 1}$

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

$$\boxed{gH = \eta^{\pm 1}\left(u_2 c_{u2} - u_1 c_{u1}\right)}$$

+1 Arbeitsmasch.

-1 Kraftmasch.

c_{u2}, c_{u1} sind von $\dot{V}$ abhängig.

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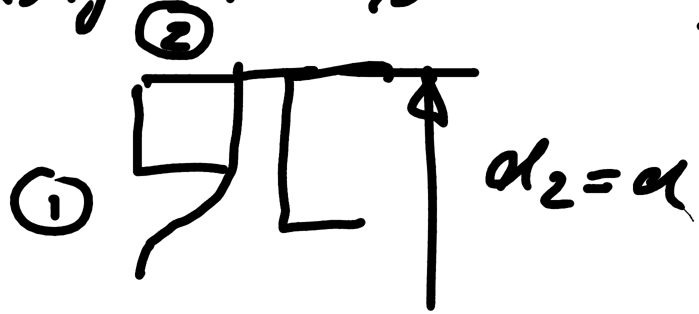
$$gH = \eta^{\pm 1}\left(u_2 c_{u2} - u_1 c_{u1}\right) \Big| \frac{1}{u_2^2/2}$$

u Betrag der Umfangsgeschwindigkeit des Laufrades.

$$\vec{u} = u\,\vec{e}_\varphi$$



c_u ist die Umfangskomponente der Absolutgeschwindigkeit

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

$$\frac{gH}{u_2^2/2} = \psi = \eta^{\pm 1}\left(\frac{c_{u2}}{u_2} - \underbrace{\frac{d_1}{d_2}\,\frac{c_{u1}}{u_2}}_{\text{Vordrall}}\right)$$

Spezialfall: kein Vordrall

$$c_{u1} \equiv 0.$$

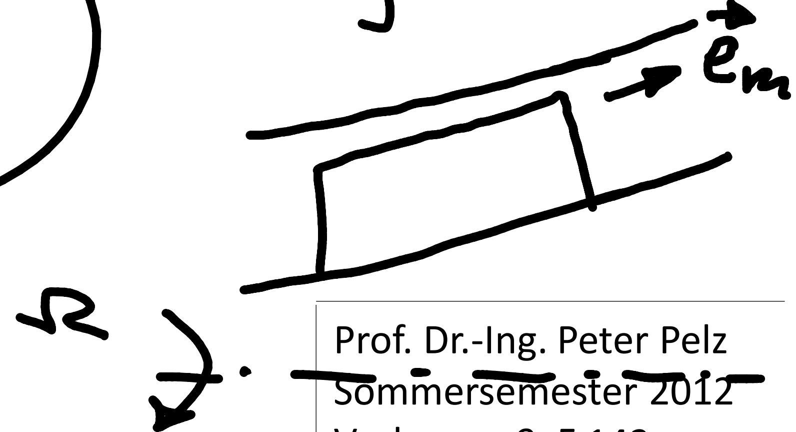
$$\psi = \eta^{\pm 1} \frac{c_{u2}}{u_2} = \eta^{\pm 1}\left(1 - \overbrace{\frac{w_{m2}}{u_2}}^{\varphi} \operatorname{ctg} \beta_2\right)$$

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

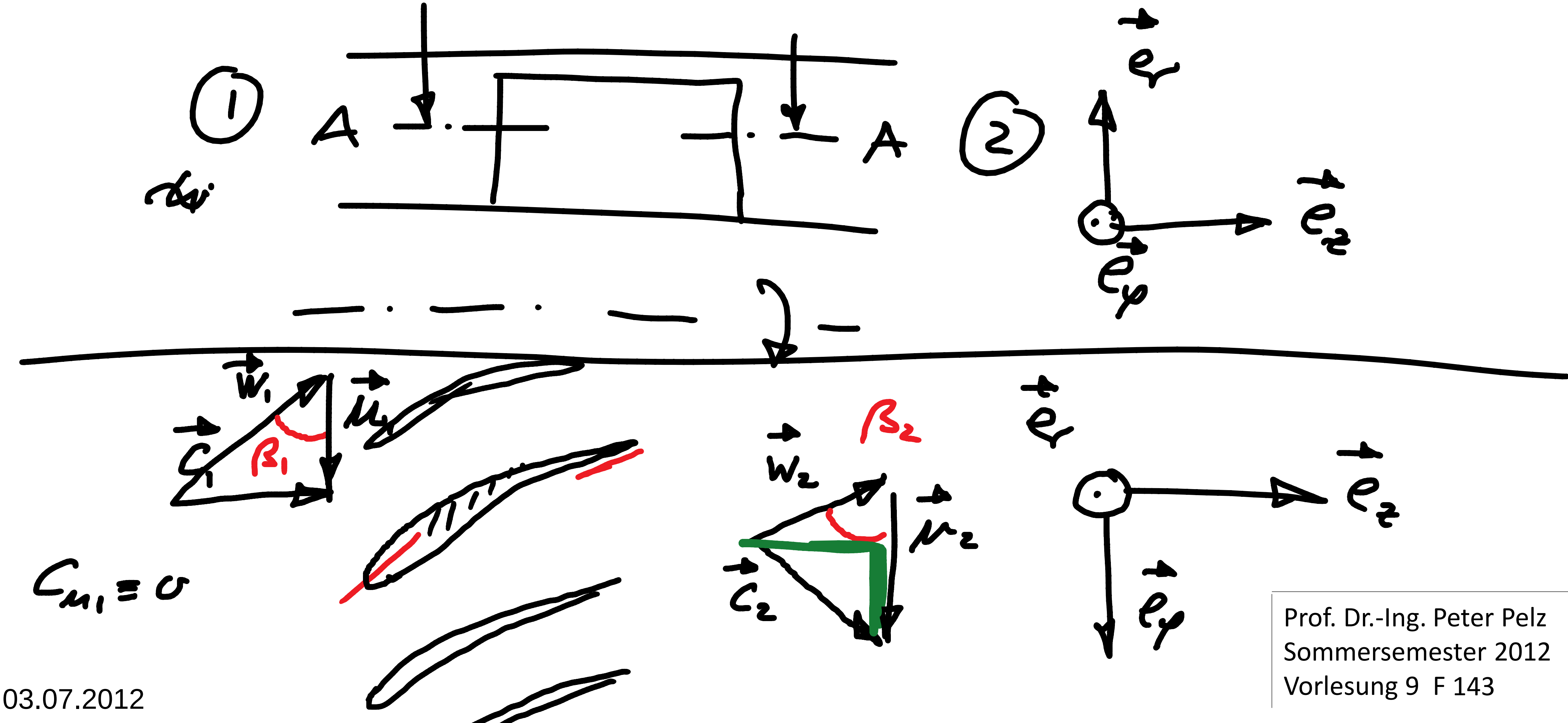
$$= w_{u2} + u_2$$

$$= -w_{m2} \operatorname{ctg} \beta_2 + u_2$$

$$\dot{V} = \int w_m \, dS$$



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



$c_{u1} = 0$