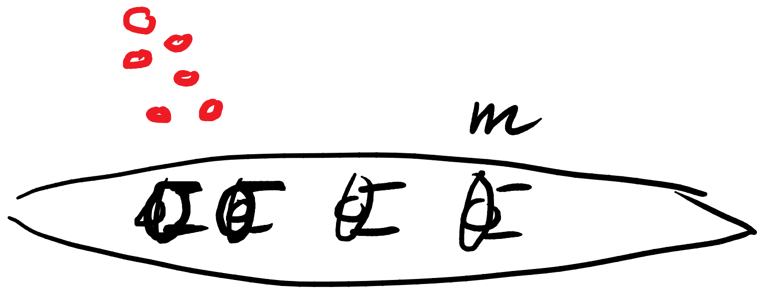
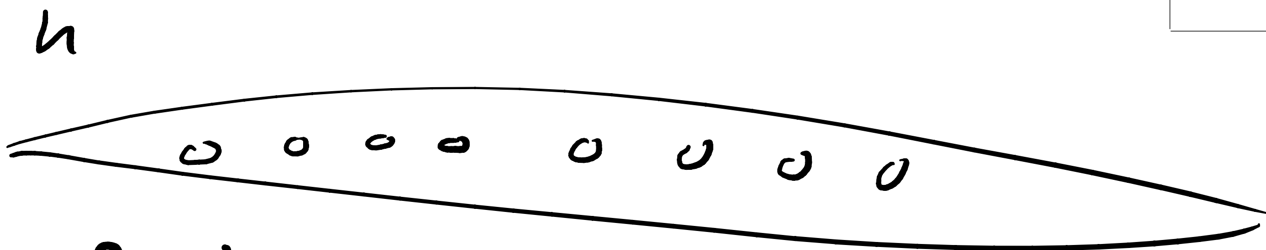
$\bar{u} \longleftarrow$





ρ

	$\bar{u}$	ε	m	ρ	n
L	1	2	0	-3	0
M	0	1/4	1	1	0
T	-1	-3	0	0	0
N	0	-1/4	-1	0	1

$$\Longleftrightarrow \Pi = \frac{\bar{u}\,\rho^{1/3}}{\varepsilon^{1/3}\, m^{1/36}\, n^{1/3}} = \text{const.}$$

$$\Longleftrightarrow \bar{u} = \underset{\overset{\shortparallel}{2}}{\Pi}\, n^{1/3}\, m^{1/36}\, \varepsilon^{1/3}\, \rho^{-1/3}$$

$$[\bar{P}_0] = [\varepsilon\, m^{3/4}] = [\varepsilon]\, M^{3/4}$$

$$M L^3 T^{-2} \quad N^{-1}$$

Zur Möglichkeit

1.) Bedingung $\Pi = \text{const}$ mit Hilfe Umwelt

$\Leftrightarrow \overline{\Pi}$ für $\varepsilon = \text{const}$ ♂

z.B. Siegerzeiten der Männereiner

↳ Vorlesung der Siegerzeiten aller Boote ✓

Fig.: 4.

2.) Energiebilanz für das System „Ruder"
im zeitlichen Mittel.

$n\overline{P_0} \longrightarrow \overline{MT}$

Eingang

mechanische Verlust.

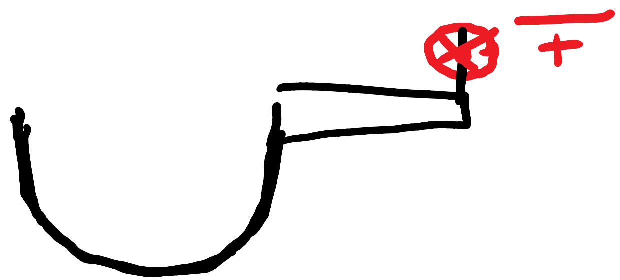
Hydrodynamik Verlust

$\eta_{Fr.}$

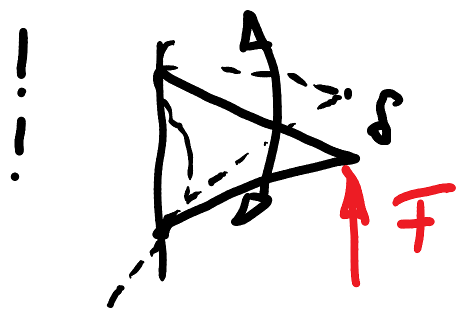
Nutzleistung

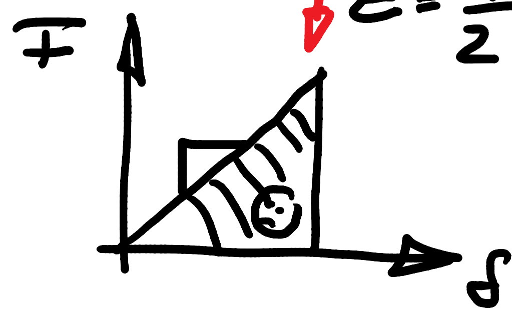
T nutzbar

$$\eta_M := \frac{\overline{P_s}}{n\overline{P_0}} = 1 - \frac{\varepsilon}{\tau P_0}$$



$k = \frac{dF}{d\delta}$ $\Rightarrow$ Steifigkeit hilft!





$E = \frac{1}{2}\frac{F^2}{k}$ Verlustenergie, da komplett dissipiert im Takt eines Impulses geeignete Sie.

mechanische Wirkungsgrad bei einem repetierenden Syst.

$$\eta_M := 1 - \frac{E}{\tau \bar{P}_0} = 1 - \frac{1}{2}\frac{\bar{F}^2}{k \tau \bar{P}_0}$$

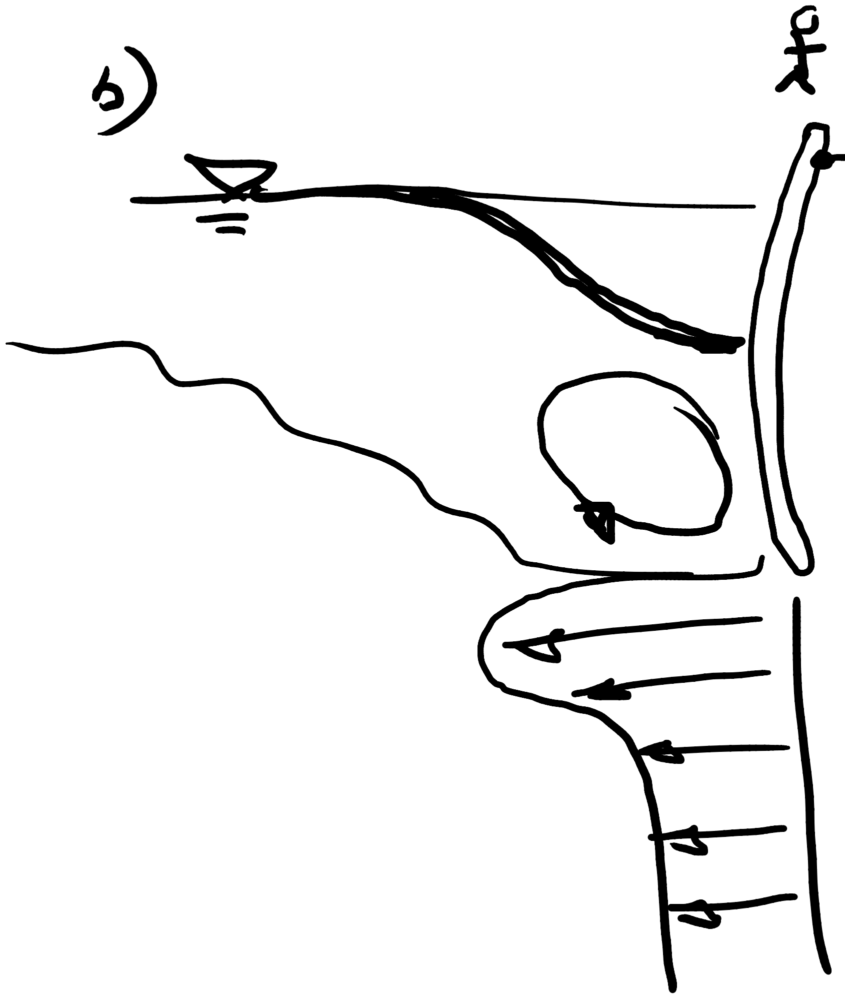
τ Periodendauer.

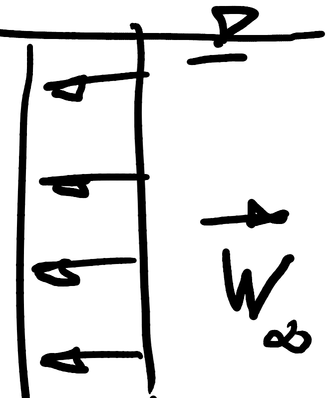
1972 wurde erstmals GFK anstelle von Holz.

Hydrodynamischer Vorteile:

Fluß der kinetischen Energie infolge Propulsion.

b)





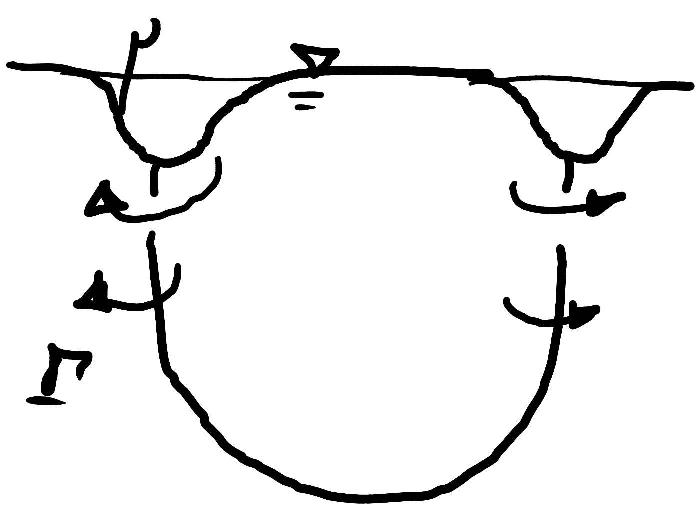
a)

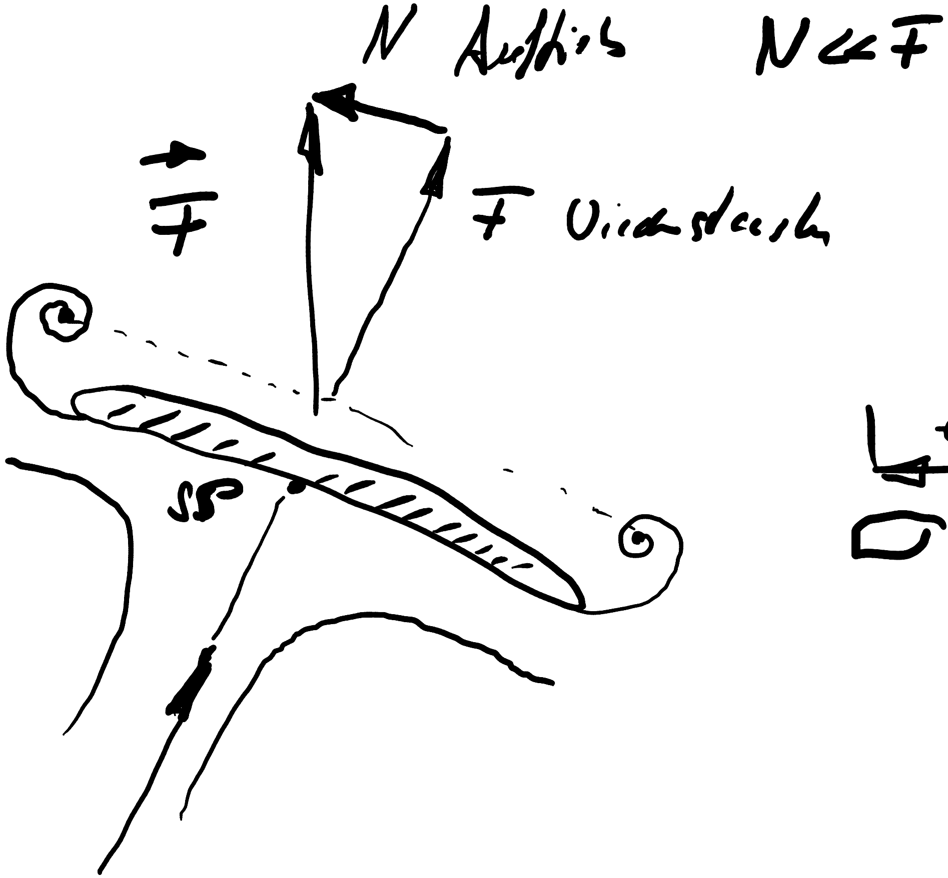
$$I' = \frac{dK'}{dW_\infty}$$

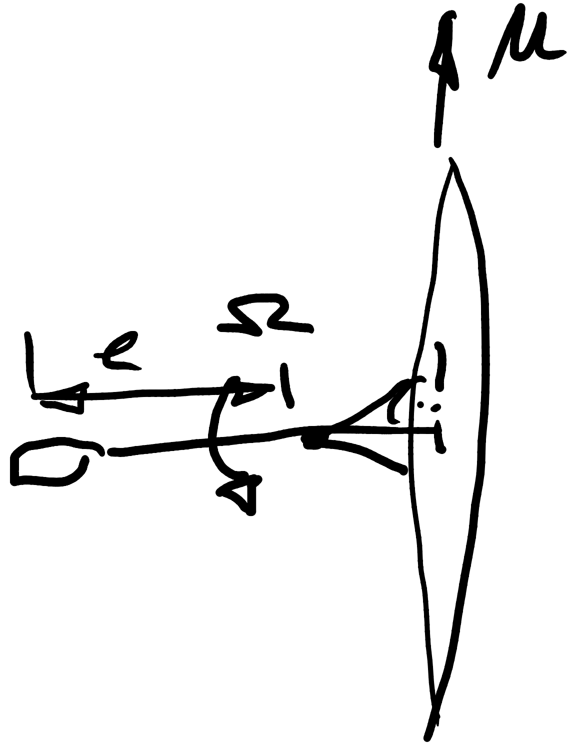
$$K' \sim W_\infty^2$$

$\vec{W}_\infty$ kinetische Energie der Strömung um das Blatt

Dimpel







$$\vec{c}_\infty = 0 = \vec{w}_\infty + \vec{u} + \vec{\Omega} \times \vec{e}$$

im ruhenden Wasser.

$$\rightsquigarrow \quad w_\infty \le \Omega e - \bar{u}$$

kinetische Energie der Strömung um das Ruderblatt

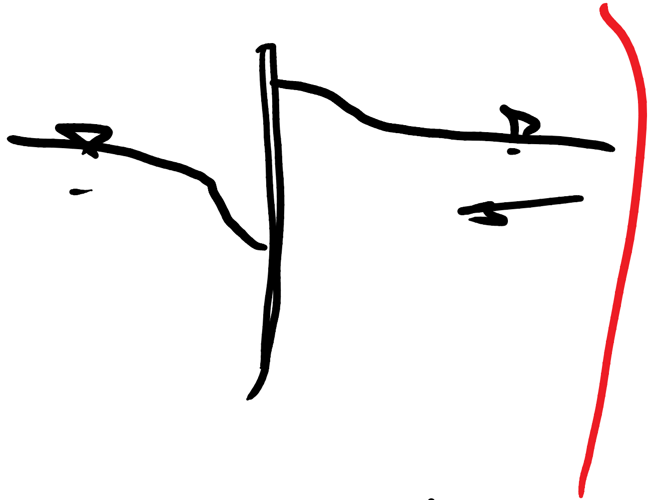
$$K' = \int_V \frac{\rho}{2} \vec{w} \cdot \vec{w} \, dV \sim W_\infty^2$$

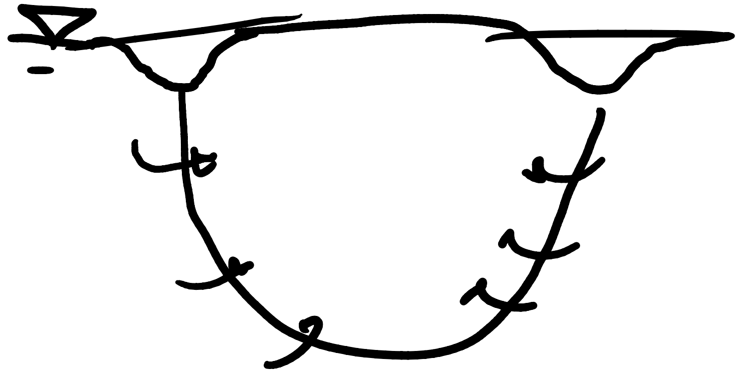
ideale Flüssigkeit

Impuls der Strömung im Rahmen des Beobachters für eine reibungsfreie / Dissipationsfrei

$$I' = \int_V \rho \vec{w} \cdot \vec{e}_x \, dV = \frac{dK'}{dW_\infty}$$

Virtuelle Masse.





$$U' = \frac{1}{2} m' W_\infty^2 = K$$

$$I' = I$$

s. I. Tage.

$$I = m' W_\infty$$

$$\Rightarrow K = m' \frac{1}{2} W_\infty^2$$

↳ Im zeitlichen Mittel ist
$\propto$ Schub pro Rotorblatt

$$T \sim \frac{I}{\tau}$$

$$\eta_F := \frac{\overline{uT}}{\overline{P_F}} = \frac{1}{1+\dfrac{\overline{P_{loss}}}{\overline{uT}}} = \frac{1}{1+\dfrac{\overline{K}}{\overline{dK/dw_\infty}\,\overline{u}}} = \boxed{\frac{1}{1+\dfrac{1}{2}\dfrac{w_\infty}{\overline{u}}}}$$

$$\frac{\overline{P_{loss}}}{\overline{uT}} = \frac{\overline{K/\cancel{\tau}}}{\overline{uI/\cancel{\tau}}} = \frac{\overline{K}}{\overline{u}\,\overline{\dfrac{dK}{dw_\infty}}}$$

$$\boxed{\eta_{Tr} = \eta_H \frac{1}{1 + \frac{1}{2}\frac{w_\infty}{\bar{u}}}}$$

Gilt auch für Strahltriebwerke oder Propeller

vgl. Prandtl: Strömungslehre

Betz: Strömungsmaschinen

η_H hydraulischer Wirkungsgrad.

$$\eta_H := 1 - \frac{\overline{P_{Verlust}}}{\overline{P_S}}$$

TECHNISCHE UNIVERSITÄT DARMSTADT

FLUID SYSTEM TECHNIK

Biofluidmechanik

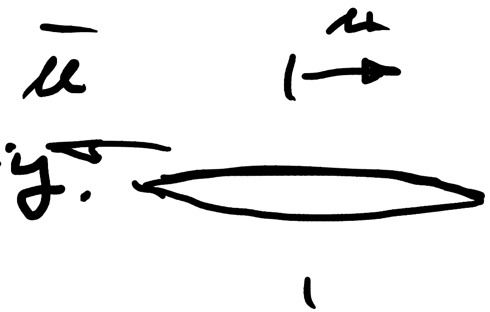
Wichtig $\eta_{Fr,ideal}$ hängt nicht
von der Form des Widerstandskörpers ab!

$\eta_{H}(Re, Fr, \text{Gestalt}) \dots$

Fortschrittsgrad $\lambda := \frac{\bar{u}}{\Omega e} = \frac{\bar{u}}{u}$, mit $u = \Omega e$.

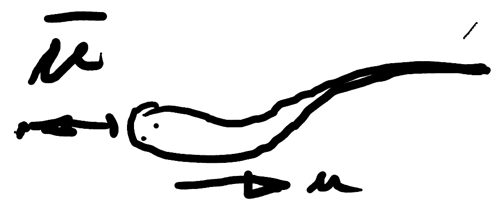
$$\eta_{Fr,ideal} = \frac{2\,\bar{u}/u}{1+\bar{u}/u}$$

Rowing:



$$\eta_{Fr,id} = \frac{1}{2}\left(1+\bar{u}/u\right)$$

Aal

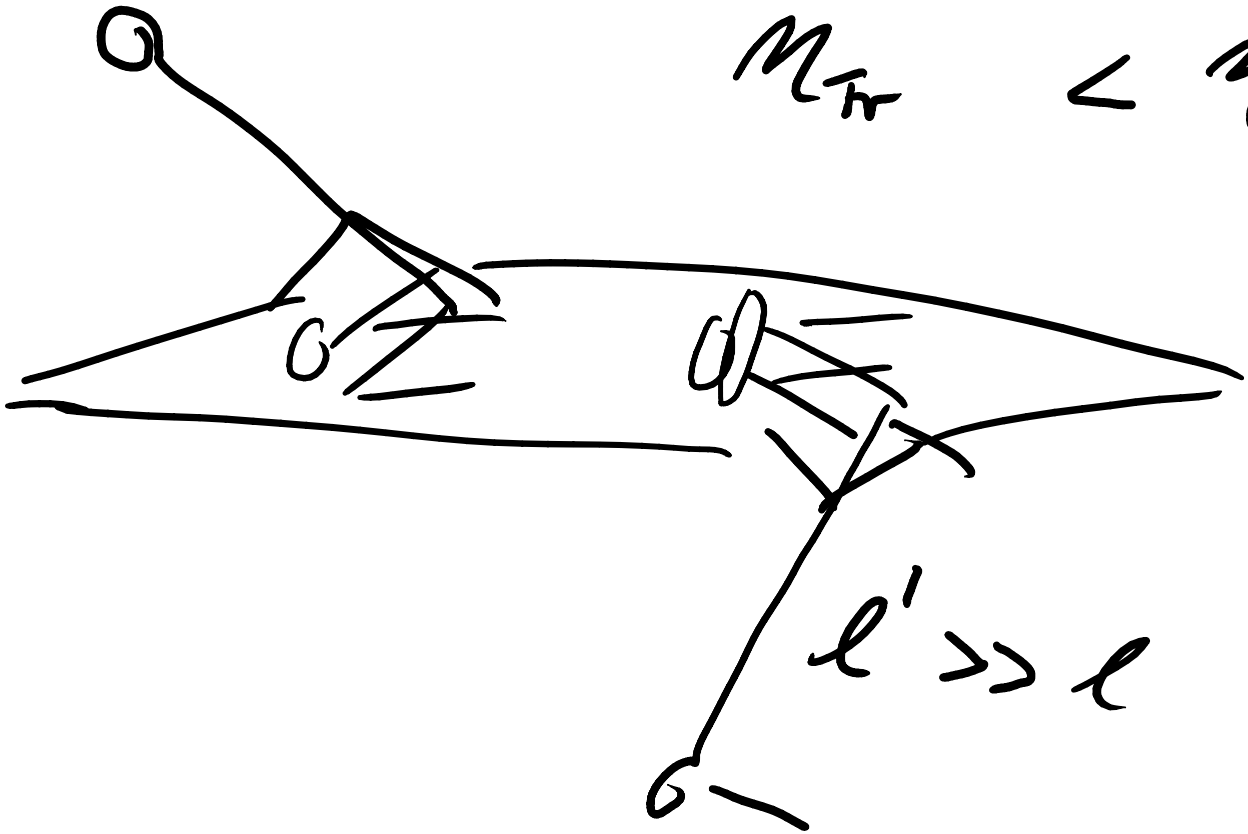


Ω sollte klein sein!

l sollte klein sein!

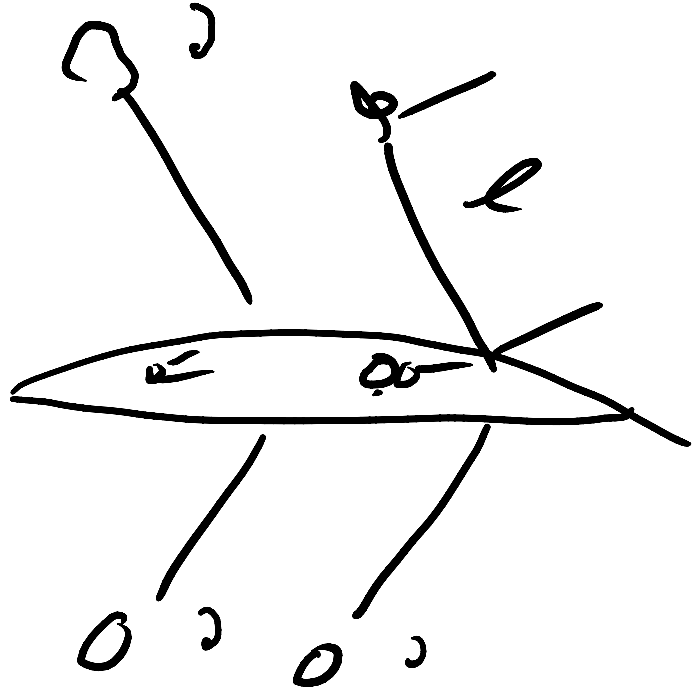
$\eta_{Tr} \uparrow$

$\eta_{Tr} < \eta_{Tr.}$



$l' \gg l$

Sweep Rowing

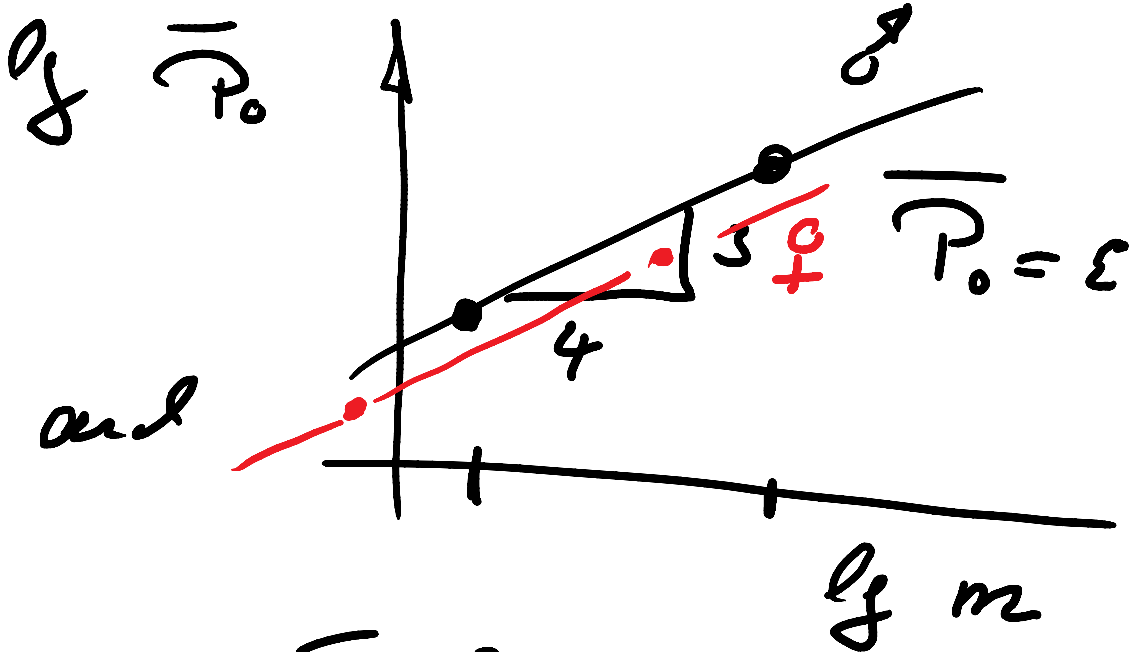


Scalling.

$$\bar{u} = \left(\frac{2}{\varkappa \bar{c}_D}\right)^{1/3} \left(\frac{2\lambda}{1+\lambda}\right)^{1/3} (\eta \varepsilon)^{1/3}\, m^{1/36}\, n^{1/3}\, \rho^{-1/3}$$

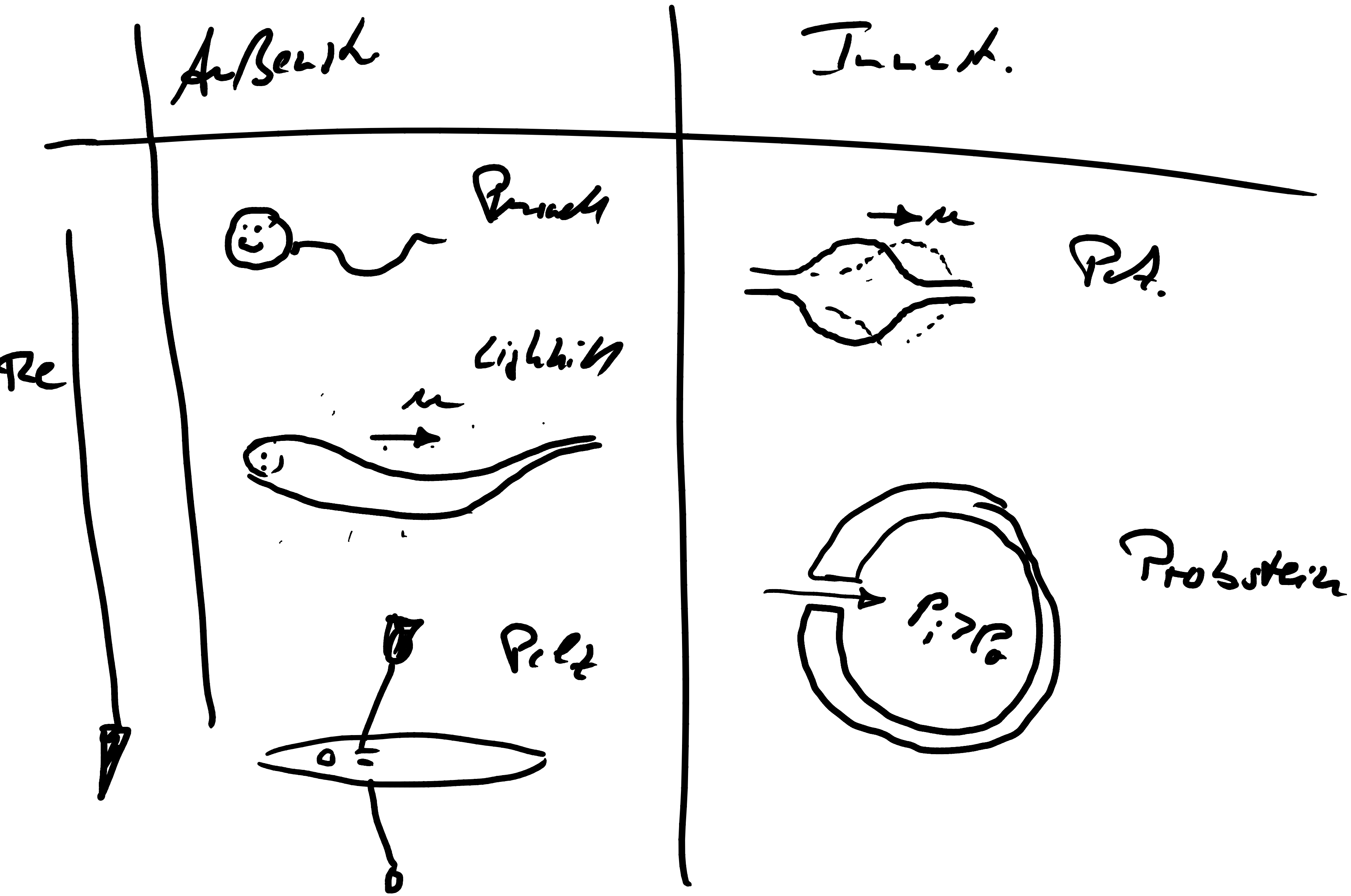
$$\eta = \eta_H \eta_M$$

Frage: Gilt das Ueberkreuz auch für Frauen?



$$\bar{P}_0 = \varepsilon\, m^{3/4}$$

Fig. 3.


Re
Purcell
Lighthill
u
Pelz
u
Probstein
$p_i > p_a$