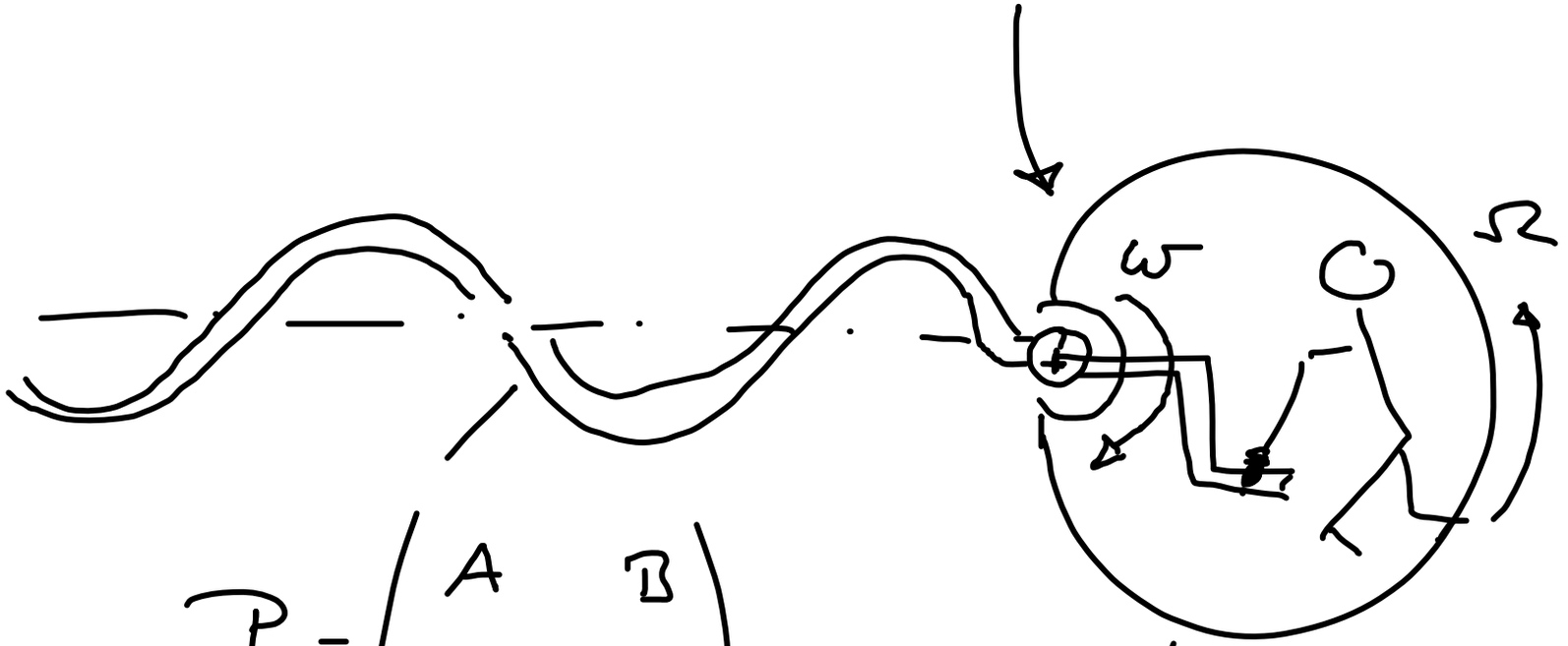
Mikrogetriebe

http://cronodon.com



$$\underline{P} = \begin{pmatrix} A & B \\ B & D \end{pmatrix} \qquad \underline{P}_0 = \begin{pmatrix} A_0 & \sigma \\ \sigma & D_0 \end{pmatrix}$$

$$\eta_F := \frac{M^2 A_0}{\Omega_m M} = \frac{A_0 B^2}{(A_0 + A)^2 D}$$

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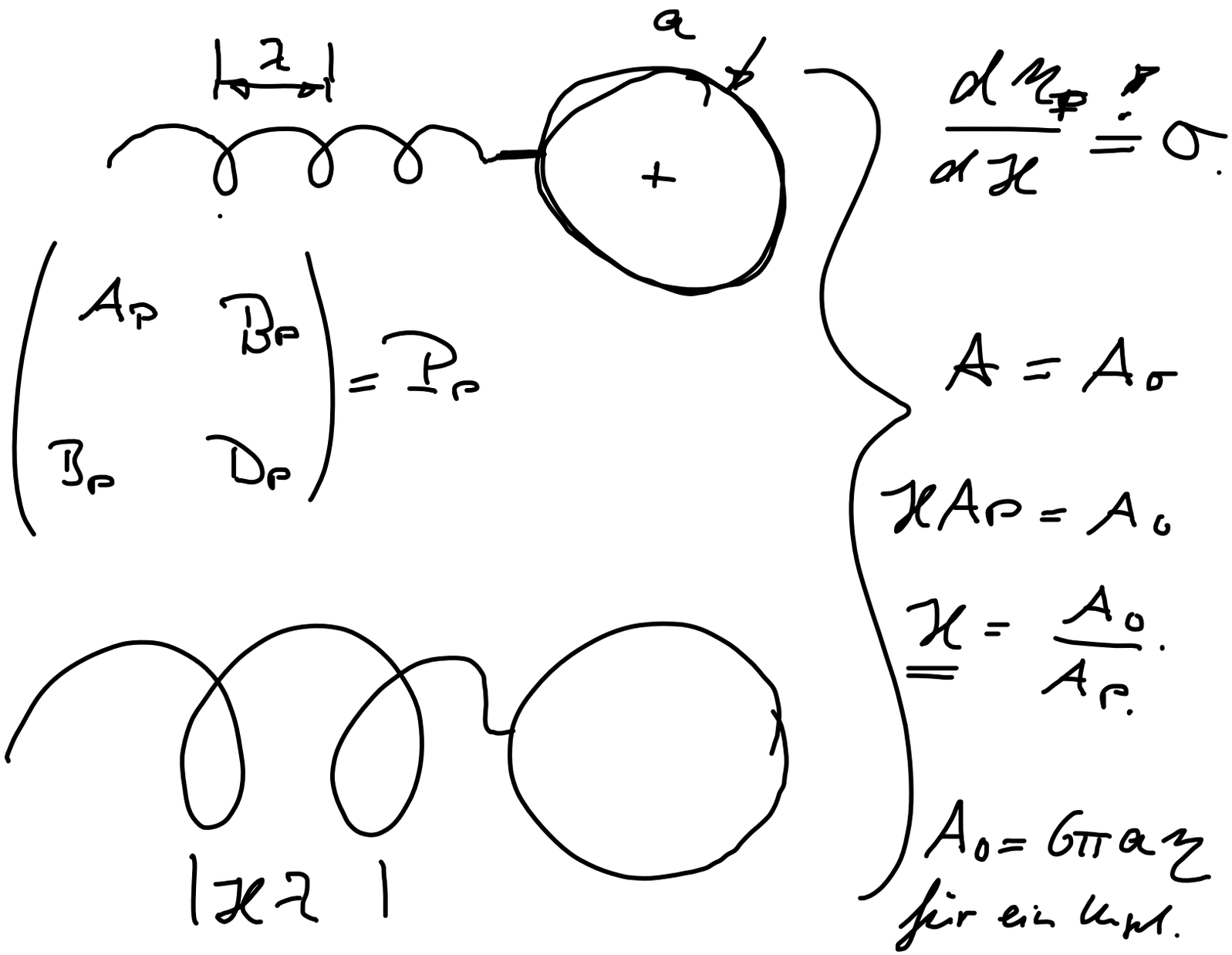

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$\chi_{opt} = \frac{A_0}{A_P}$ wird bezeichnet

als das Fraunhofer Widerstand.

$$\eta_{F_{opt}} = \frac{B_P^2}{4 A_P D_P}$$

besser geht nicht in der Mikrowelt

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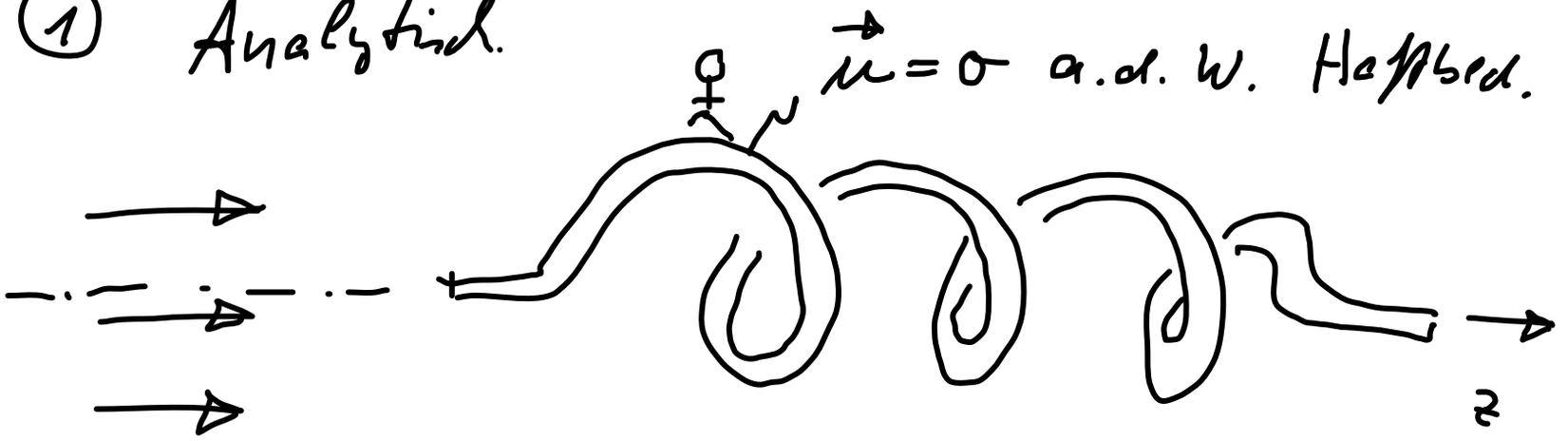
Bestimmung von A_P, D_P, B_P.

① Analytisch.



$$\vec{u}_\infty = u_\infty \vec{e}_z + r\Omega \vec{e}_\varphi$$

$\nabla p = \eta \Delta \vec{u}$ Stokesche Rbd.

Stromfunktion ψ: $\nabla\psi$

$\psi = \text{const}$ sind Stromlinien

$\nabla^4 \psi = 0$.

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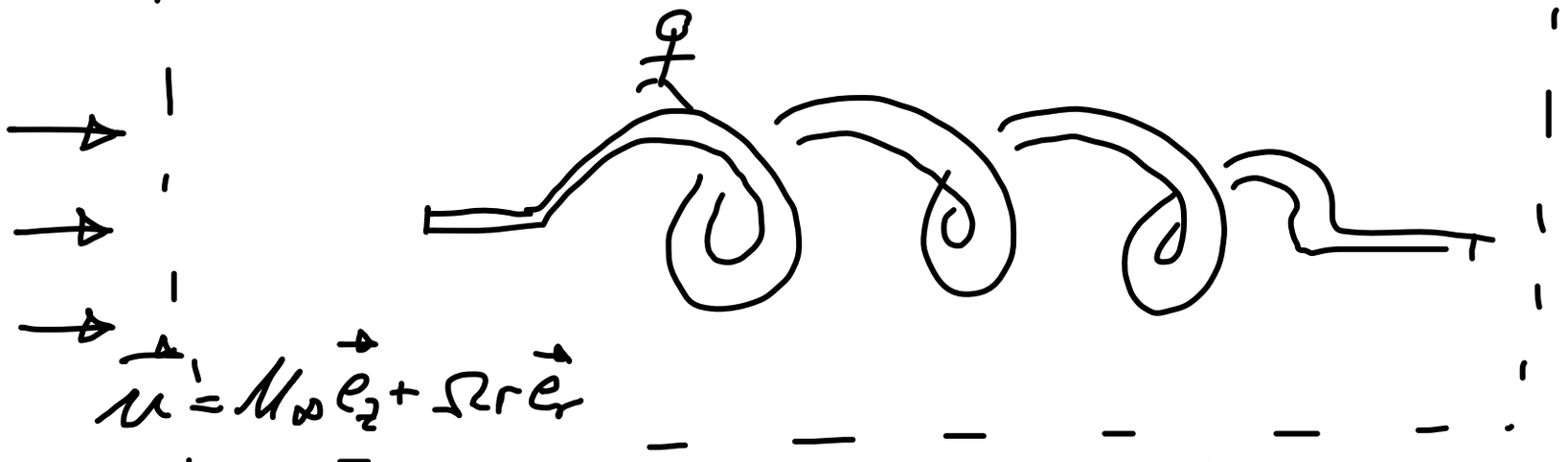
Hydrodynamik

Happel & Brenner, 1967.

Low Reynoldsnumber Hydrodynamics.

(2) CFD Rechg. $Re \ll 1$



$\vec{u} = U_\infty \vec{e}_z + \Omega r \vec{e}_r$

Problem: Störung klingt kaum ab.

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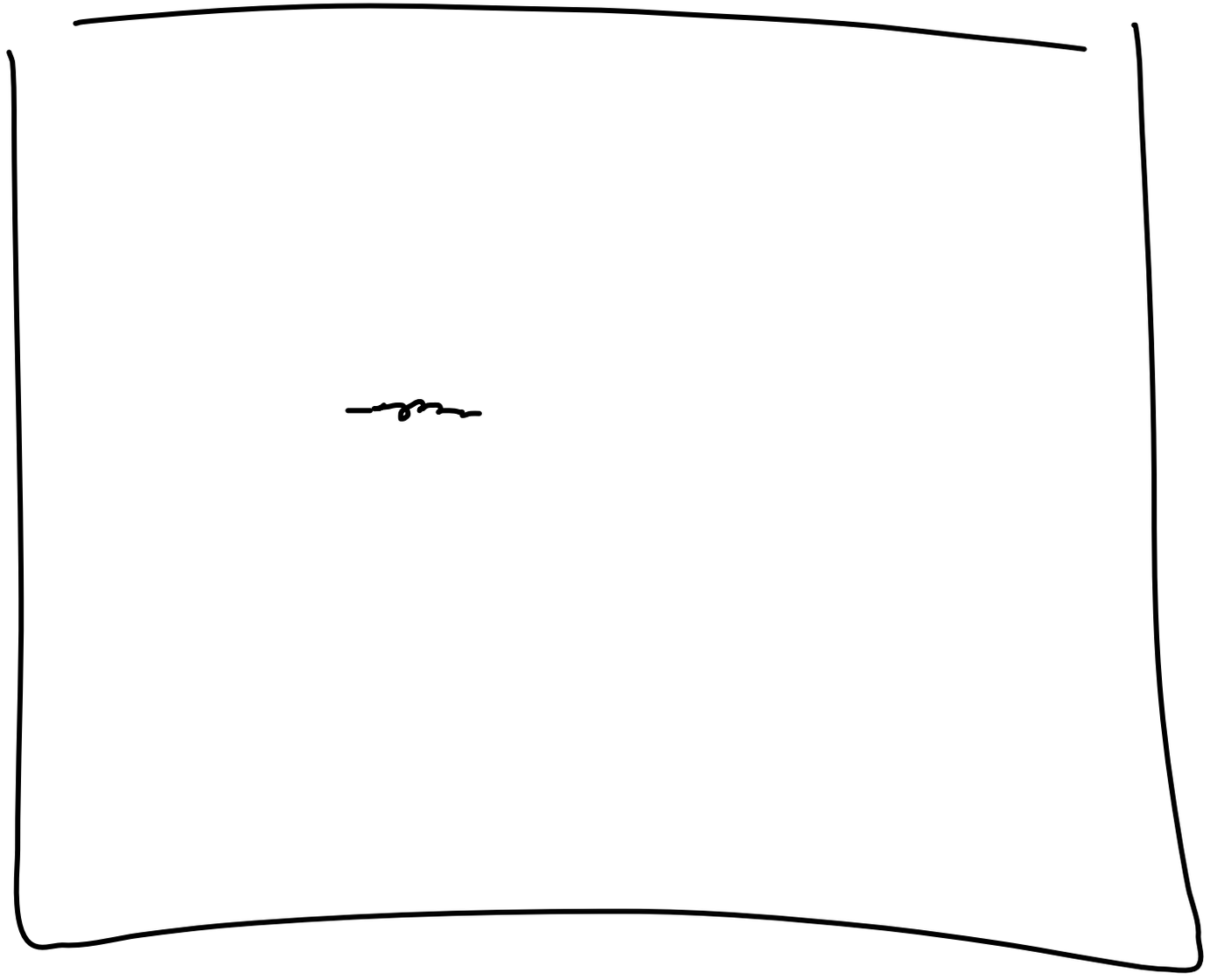

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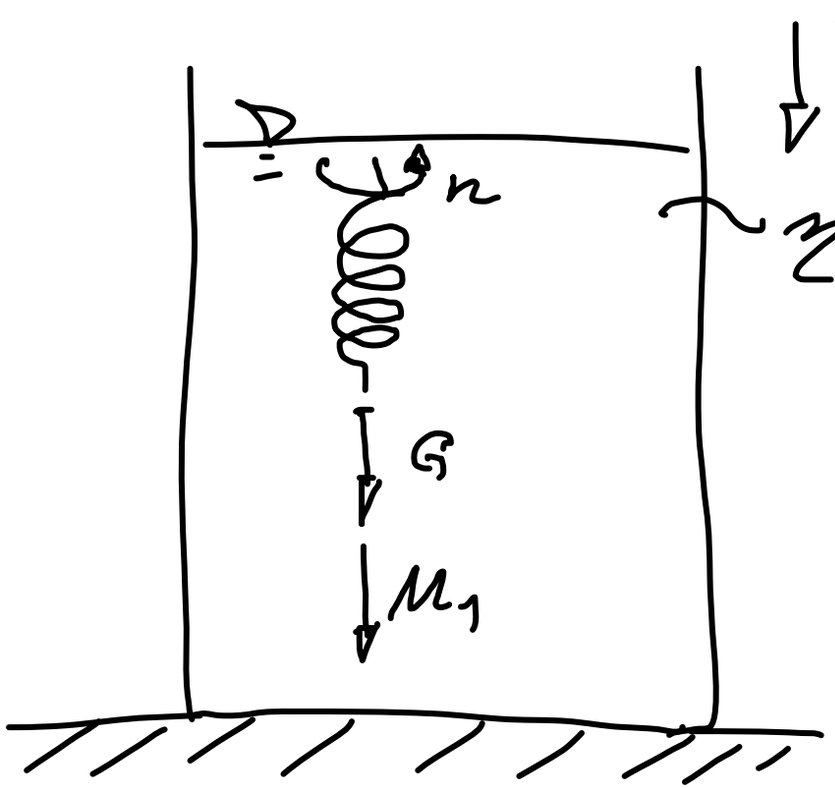
(3) Experimentelle Bestimmung von A_P, D_P, B_P



$\eta = 1\,mPa\,s$

$\Omega = 2\pi n$

$$\begin{pmatrix} A_P & B_P \\ B_P & D_P \end{pmatrix} \begin{pmatrix} M \\ \Omega \end{pmatrix} = \begin{pmatrix} G \\ 0 \end{pmatrix}$$

$$A_P M + B_P 2\pi n = G$$
$$B_P M + D_P 2\pi n = 0.$$

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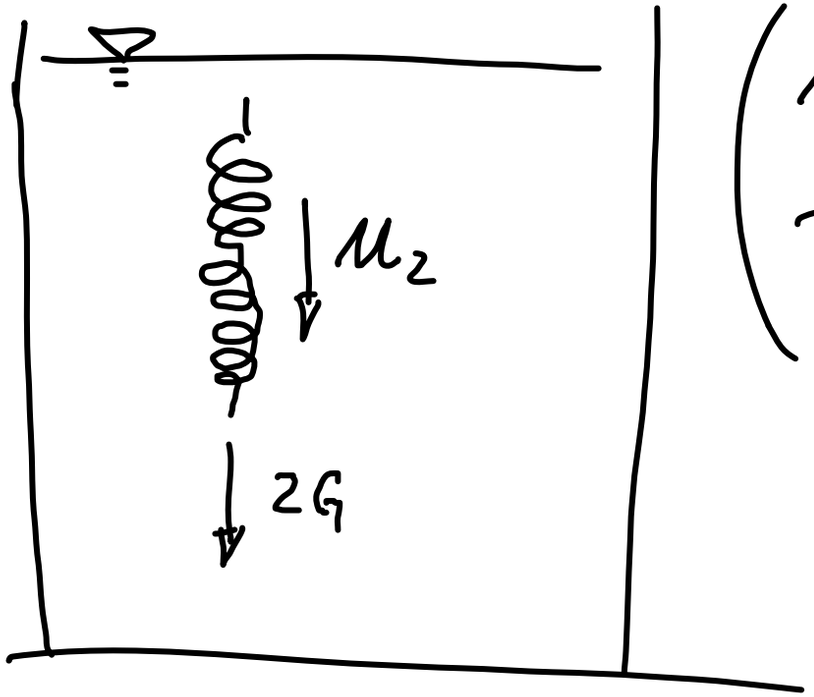

$$\begin{pmatrix} A_P & B_P \\ B_P & D_P \end{pmatrix} \begin{pmatrix} u_2 \\ \sigma \end{pmatrix} = \begin{pmatrix} G \\ \sigma \end{pmatrix}$$

$$G = A_P u_2 \rightsquigarrow A_P = \frac{G}{u_2}$$

$$G = 14\ 10^{-3}\ \underbrace{9.81}_{10}\ N = 0.14\ N.$$

$$u_2 = \frac{0.3\,m}{1.52\,sec} = 0.2\,\frac{m}{sec}$$

TEST: $Re = \dfrac{0.2\ 14\ 10^{-3}}{10^{-6}}$

~~$= 2800$~~ $= 2800$ ↯

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Hinweis: Größen mit der Dimension

Kraft / Geschwindigkeit — reziproke Mobilität.

$$\frac{A_p}{2\pi} = \frac{0.14}{0.2} \frac{N\,sec}{m\ 10^{-3}\ Pa\,sec.}$$

$$= \frac{0.14}{0.2} \frac{10^3}{6\pi}\ m$$

$$= 36\ 10^3\ cm$$

$A_p \sim \eta \lambda$

$B_p \sim \eta \lambda^2$

$D_p \sim \eta \lambda^3$

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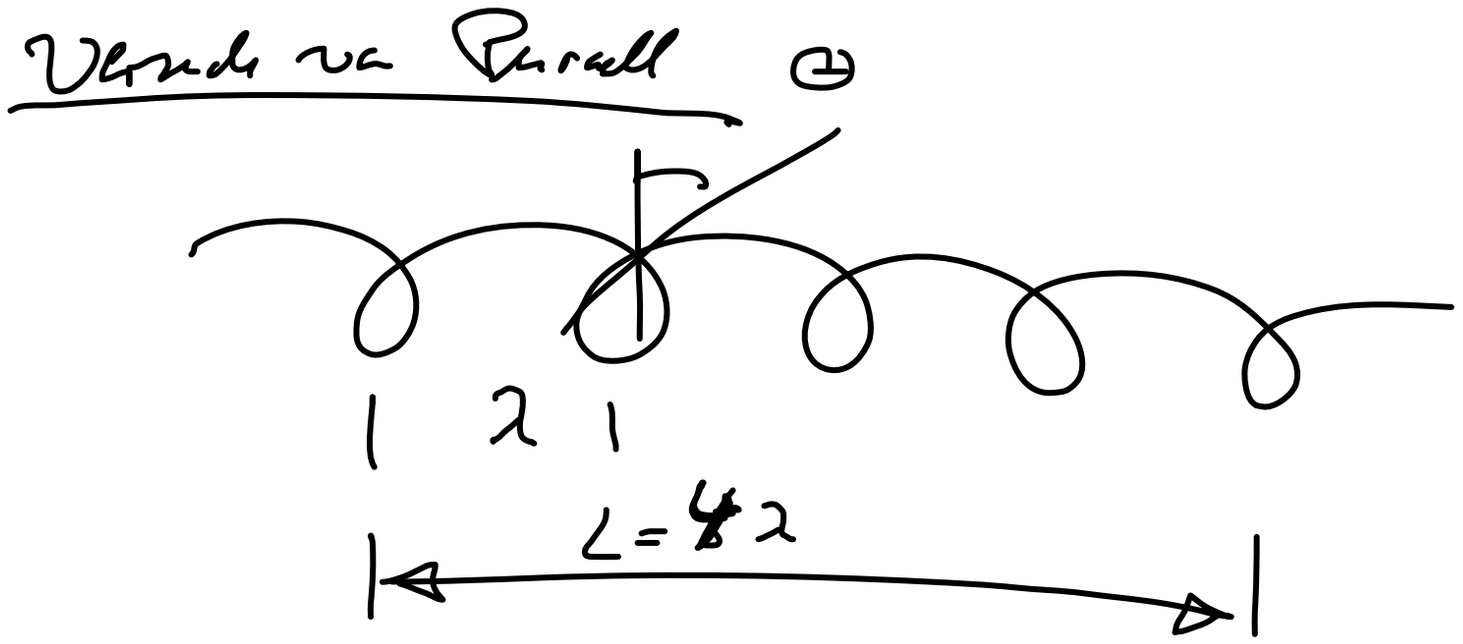

$\frac{L}{\text{in cm}}$	$\frac{L}{\lambda}$	Θ in °	$\frac{A}{6\pi\eta}$ in cm	$\frac{B}{6\pi\eta}$ in cm²	$\frac{D}{6\pi\eta}$ in cm³	η^F_{max} in %
5.2	5	55	0.67	.032	0.076	0.48
7.8	5	39	.71	.038		0.78
9.4	5	20	.74			.34
3.1	3	55	.48	⋮		.46
7.5	7	56	.91			.54

↯

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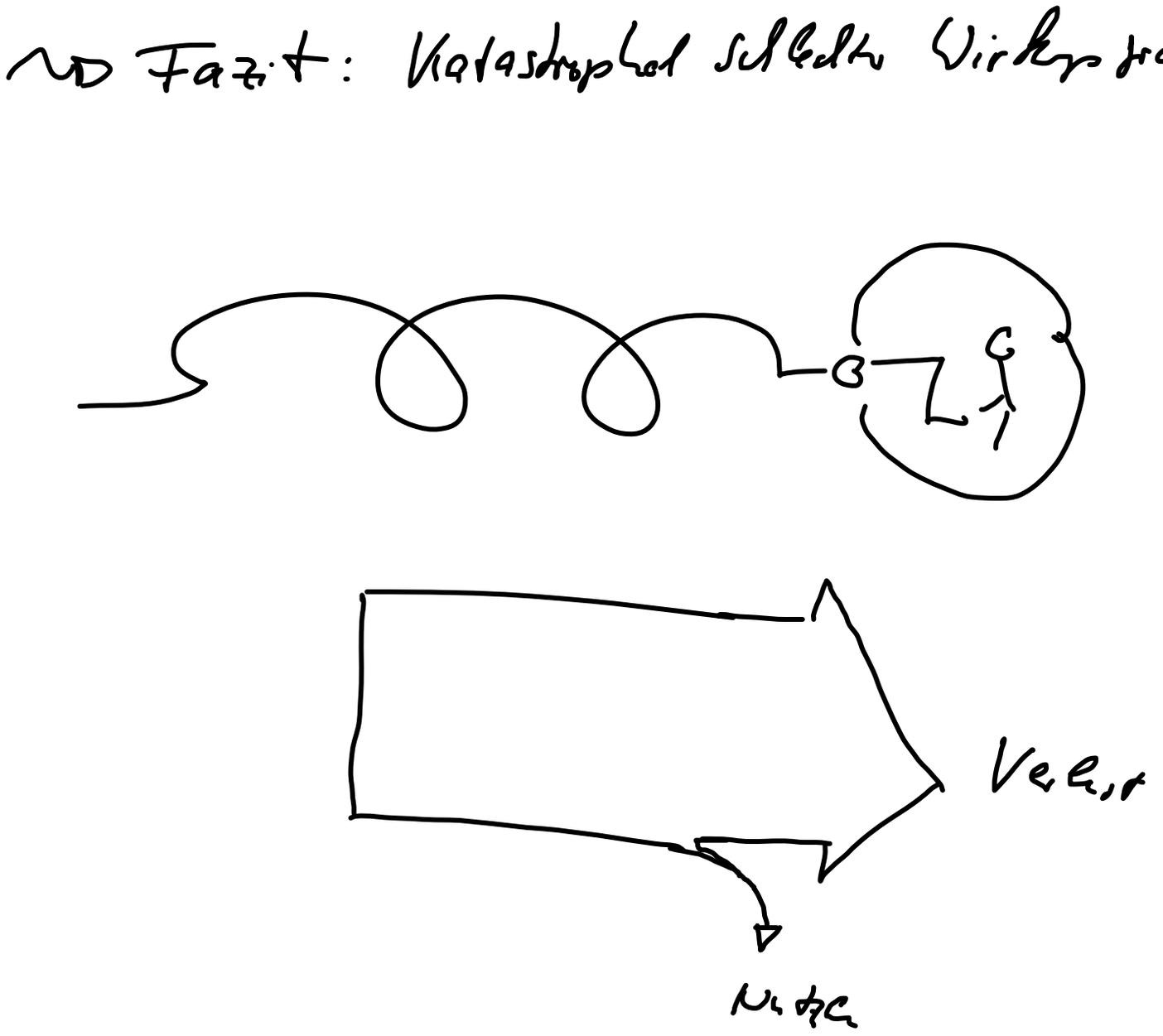

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Skalierungsgesetz für das Verdrängerprinzip.

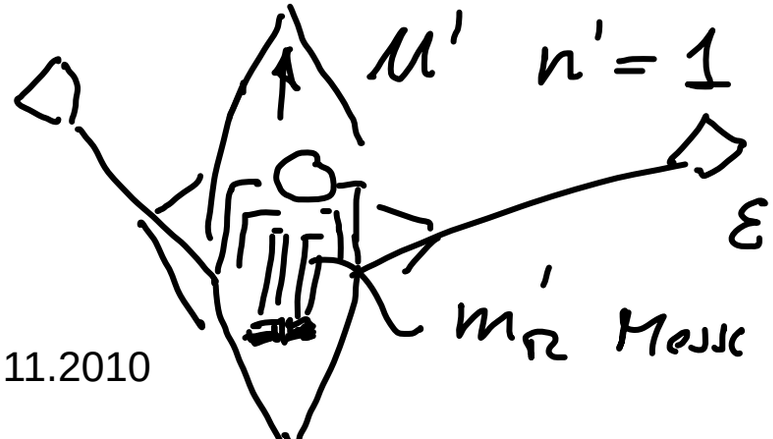
Diplomarbeit Fr Mang. 2006/2007.

$$M = \left(\frac{\varepsilon}{\varepsilon'}\right)^{1/3} \left(\frac{\eta_F}{\eta_F'}\right)^{1/3} \left(\frac{h}{h'}\right)^{1/9} \left(\frac{m_R}{m_R'}\right)^{1/36} M'$$

Skalierungsgesetz für die Bootsgeschwindigkeit.

1_ System ist das Modellboot.

$$\eta_F' = \eta_{ges} = 92 \ldots 95\%$$



M' $n' = 1$ Zahl der Ruder.

$\varepsilon' = \varepsilon_{\sphericalangle}$ Kleinste Querschnittsfläche eines Ruders.

m_R' Masse des Ruders.

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Hoher Froudescher Wirkungsgrad

Schaufeln: $\eta_F = 92 \ldots 95\%$.

Riemenantrieb $\eta_F = 81 \ldots 88\%$.

$$\eta_F = \frac{U W}{P n}$$

P zugeführte Leistung einzeln. Antriebs.

$$P = \varepsilon \, m_R^{3/4}$$

Kleibergesetz

1936

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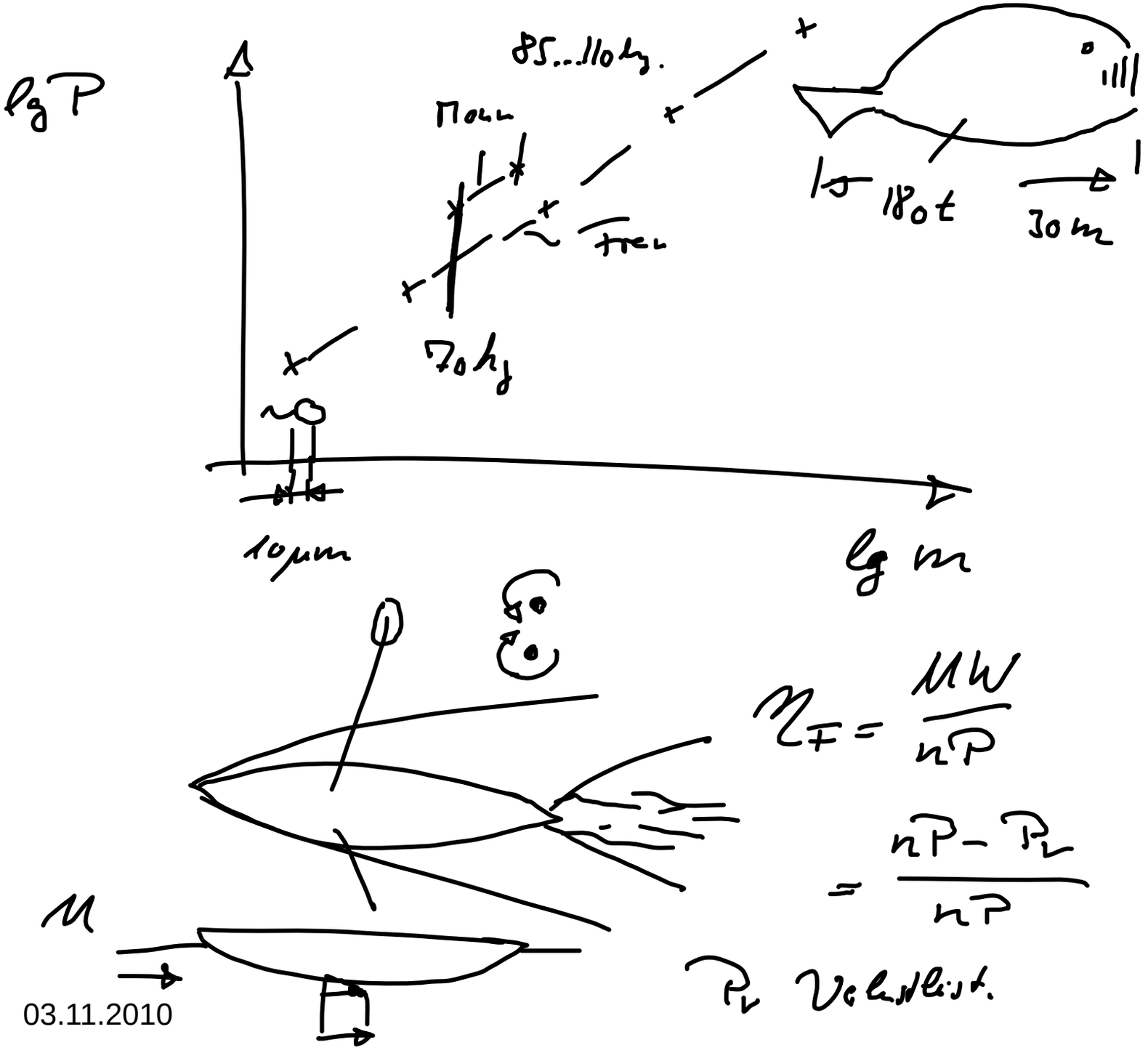

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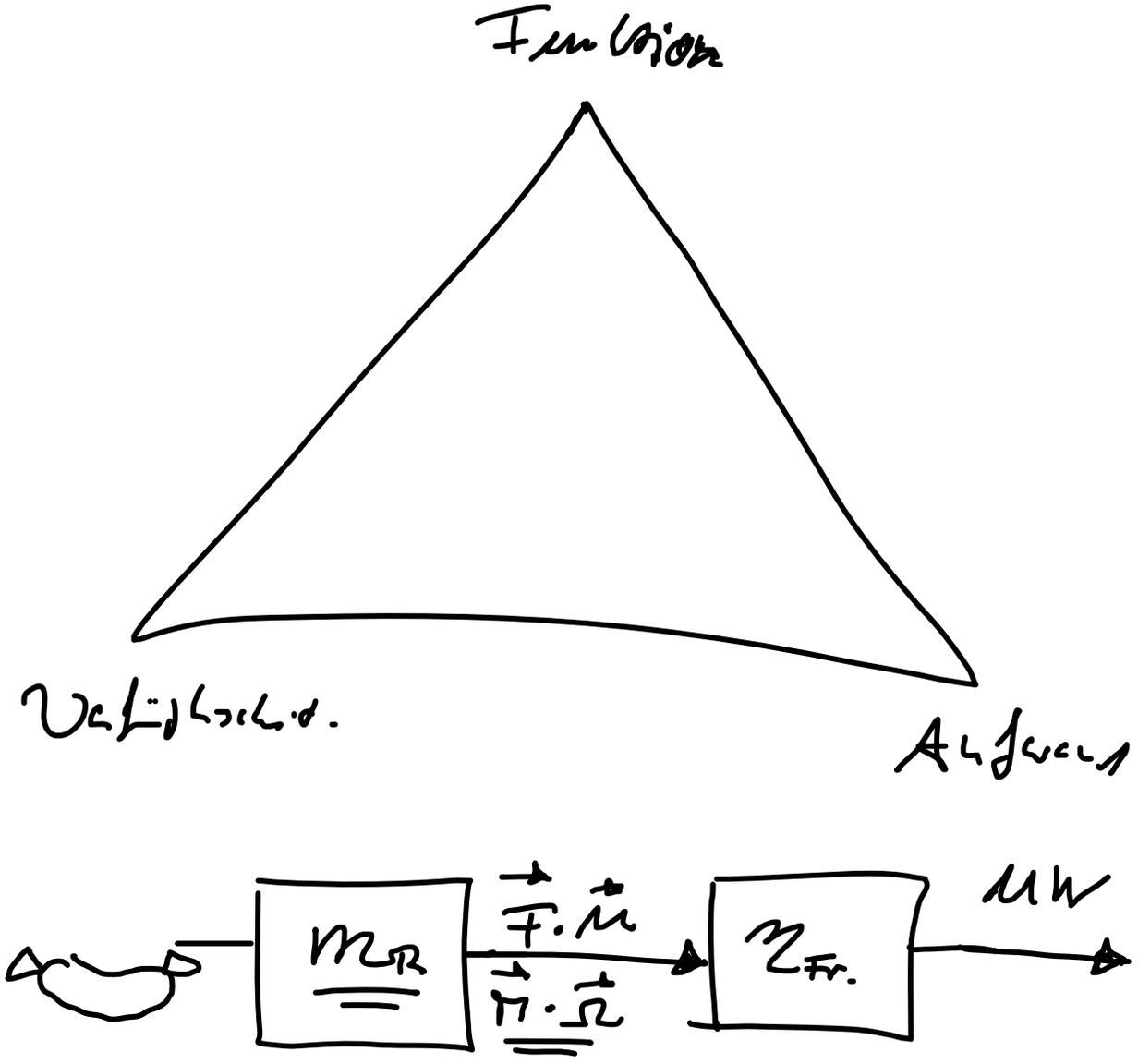

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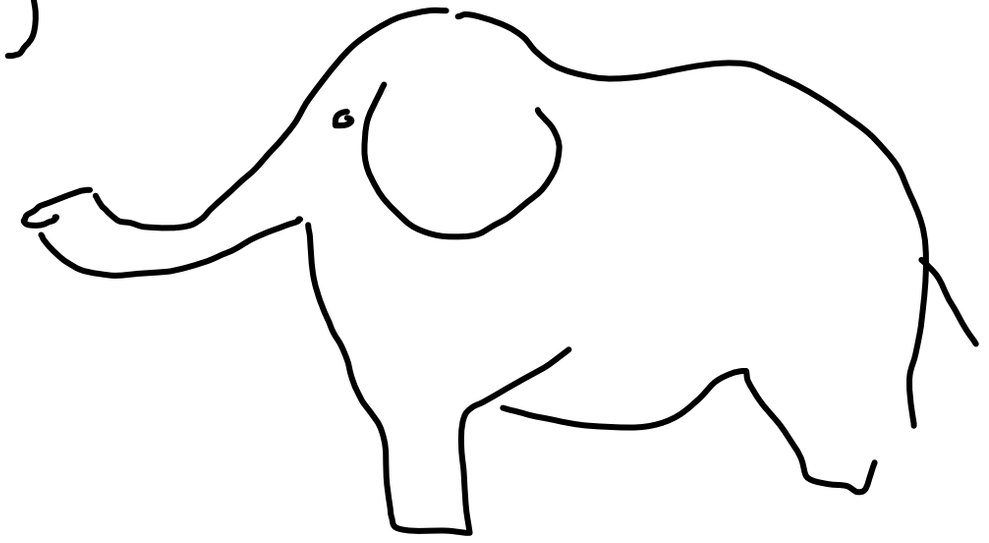
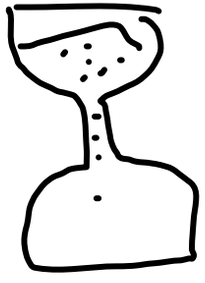
$f \sim m_R^{-\frac{1}{4}}$

$T \sim m_R^{\frac{1}{4}}$

} f_T = Zahl an Herzschläge.





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