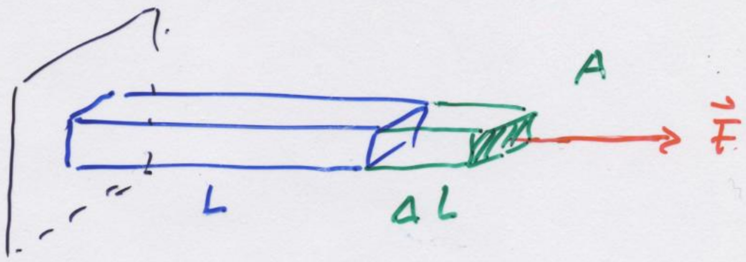
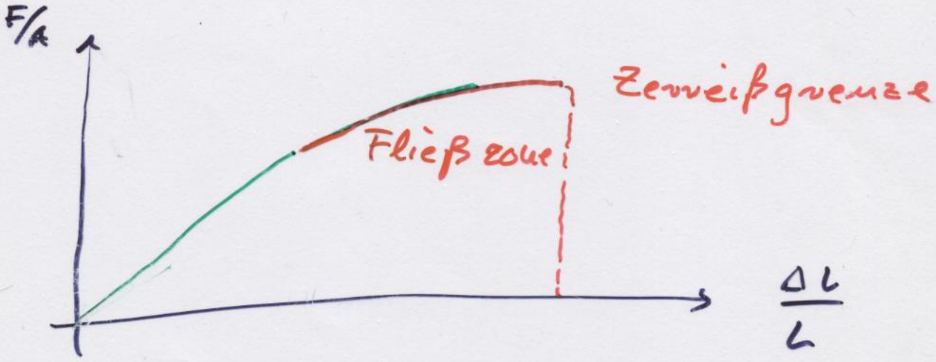
1. Elastische Verformung

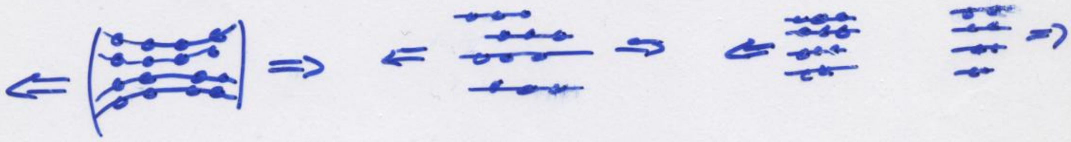
a] Hooke'sches Gesetz

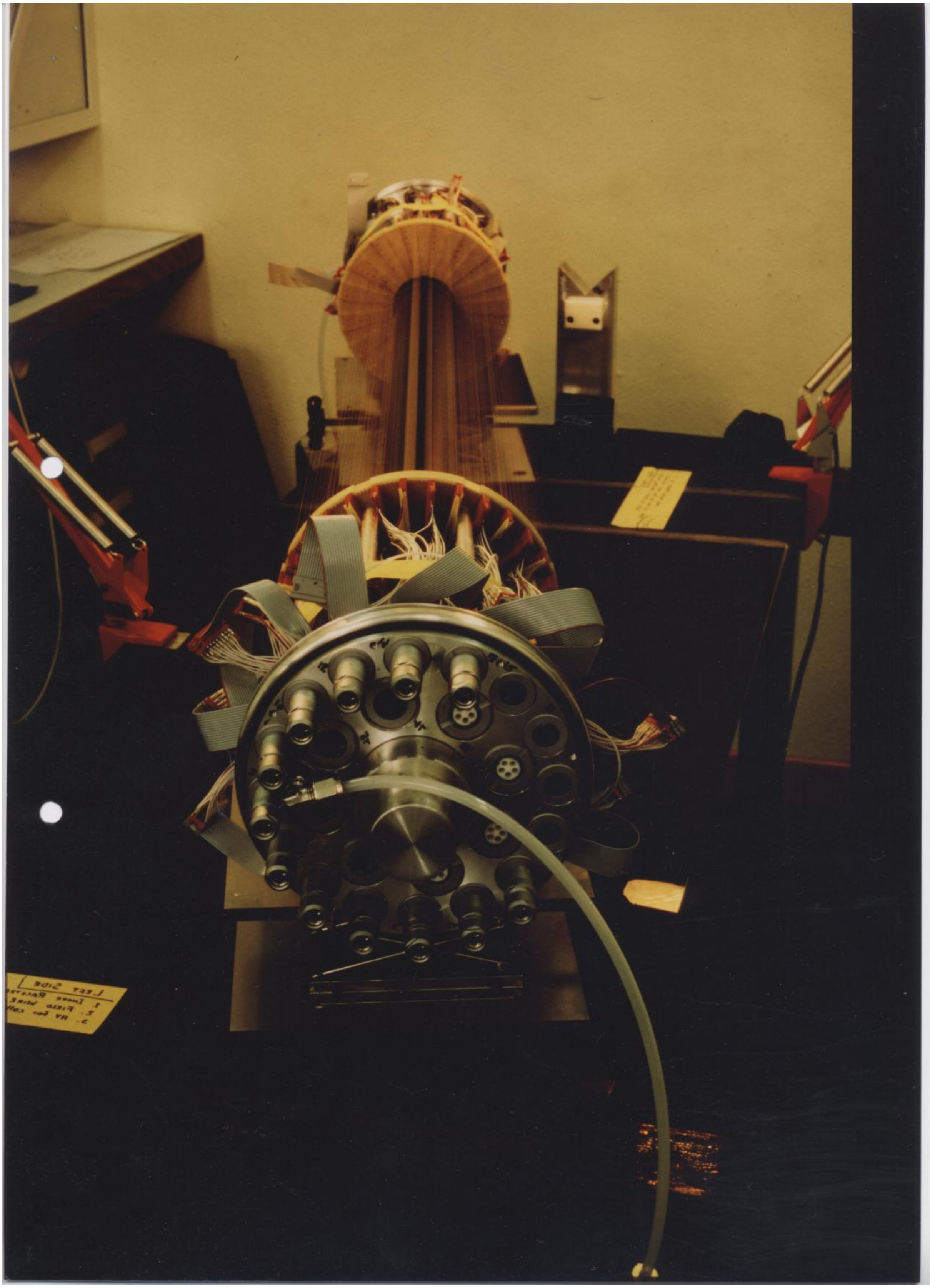


$$\frac{\Delta L}{L} = \frac{F}{A} \cdot \frac{1}{E}$$; E Elastizitäts-modul.

$$[E] = \frac{N}{m^2}$$







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THRESHOLDS		
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E	CAL	0.10
PT	CD	0.10
P	CD	0.00

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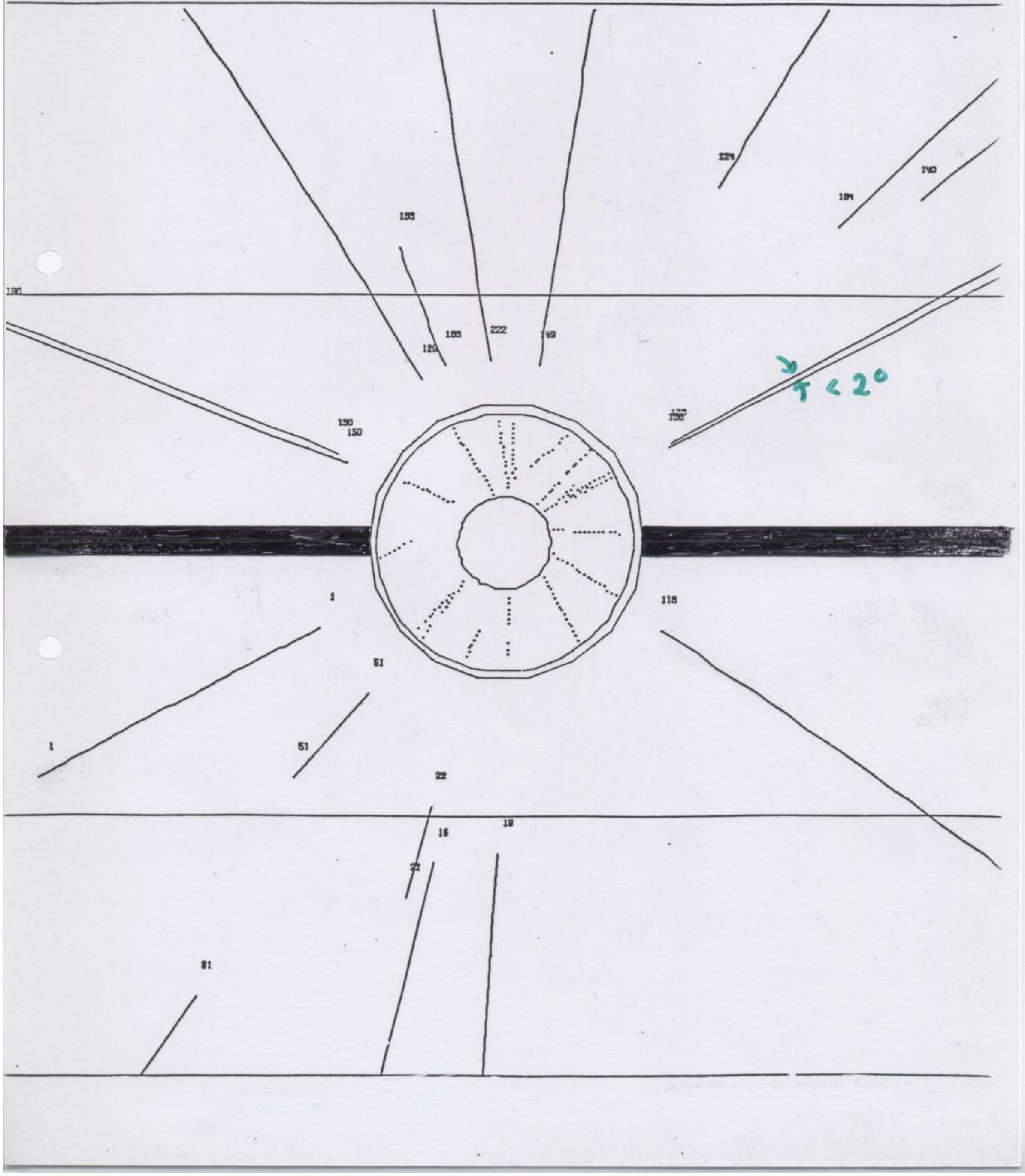
27-NOV-1985 1
WINSTON.HCY6



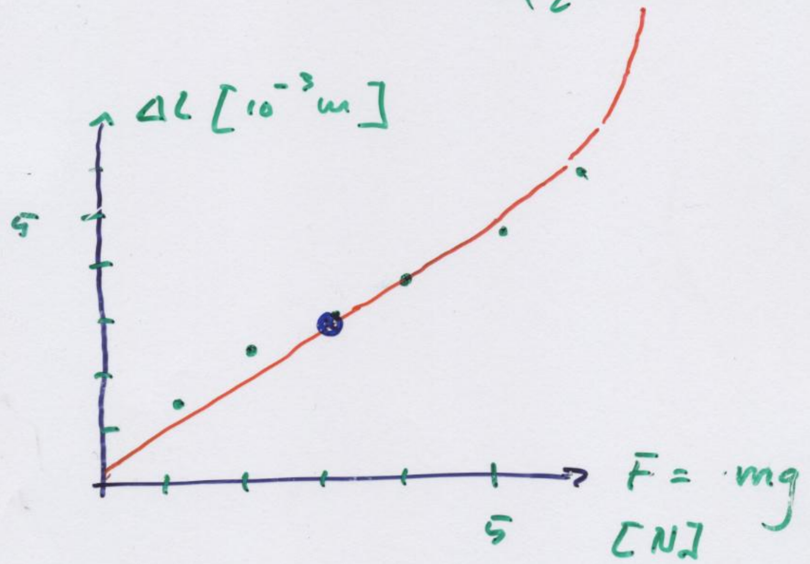
Demo   Messe $\frac{\Delta L}{L} = \frac{F}{A} \cdot \frac{1}{E}$

Kupferdraht:

$L = 450\,cm$

$d = 3 \cdot 10^{-2}\,cm$

$A = \pi \left(\frac{d}{2}\right)^2 = 0{,}7 \cdot 10^{-3}\,cm^2$



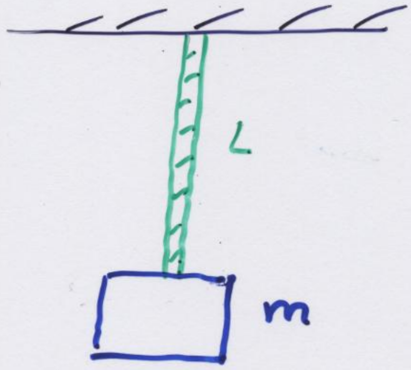
$E = \frac{L}{\Delta L} \cdot \frac{F}{A}$

$= \frac{450\,cm}{0{,}3\,cm} \cdot \frac{3\,N}{7 \cdot 10^{-4}\,cm^2}$

$= 6{,}4 \cdot 10^{10}\,\frac{N}{m^2}$

Beispiel

a) Dehnung eines Stahlkabels



$L = 2\,m$

$\varnothing = 2\,cm$

$E = 2{,}5 \cdot 10^{11}\ \frac{N}{m^2}$

$m = 9{,}5\,t$

$$\Delta L = \frac{L \cdot F}{E \cdot A}$$

$$= 2{,}4\ mm$$

b) Dehnung eines Gummibandes
selbe Maße

$E = 7 \cdot 10^6 \frac{N}{m^2}$

$\Rightarrow \Delta L = 84\,m$ (!)

Reißfestigkeit

$$\frac{F}{A} := E\left(\frac{\Delta L}{L}\right)_c = E_r$$

Verlängerung vor dem Reißen

	$E_r\ [N/m^2]$
Stahl:	$4 \ldots 30 \cdot 10^8$
Gummi:	10^7
Sehne:	10^8
Spinnenseide:	$2 \cdot 10^8$

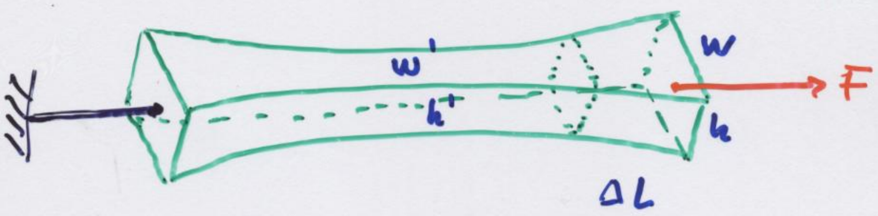
zu unserem Beispiel:

- Stahlkabel: $m_{max} = \frac{E_v \cdot A}{g}$

$= 95\ t$

- Gummi: $m_{max} = 320\ kg$

b] Volumenänderung bei Dehnung



$w' = w - |\Delta w|$

$h' = h - |\Delta h|$

$L' = L + \Delta L$

Es gilt: $\frac{\Delta h}{h} = \frac{\Delta w}{w} = -\mu \cdot \frac{\Delta L}{L}$

Poissonzahl typ. 0,3

Volumen $\quad V' = V + \Delta V$

$$\frac{\Delta V}{V} = \frac{(w + \Delta w)\cdot(h + \Delta h)(l + \Delta l)}{w \cdot h \cdot l} - 1$$

$$= \left(1 + \frac{\Delta w}{w}\right)\left(1 + \frac{\Delta h}{h}\right)\left(1 + \frac{\Delta l}{l}\right) - 1$$

$$= \left(1 - \mu \frac{\Delta l}{l}\right)^2 \cdot \left(1 + \frac{\Delta l}{l}\right) - 1$$

$$\approx (1 - 2\mu)\,\frac{\Delta l}{l}$$

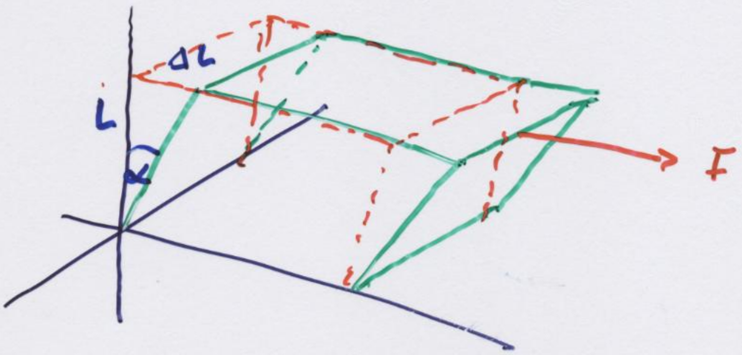
unser Beispiel : Stahlkabel

$$\frac{\Delta V}{V} = (1 - 0{,}6)\cdot \frac{\Delta l}{l}$$

$$= 0{,}4 \cdot \frac{2{,}4\ \text{mm}}{2\ \text{m}}$$

$$= 0{,}5\ ‰$$

c] Scherung



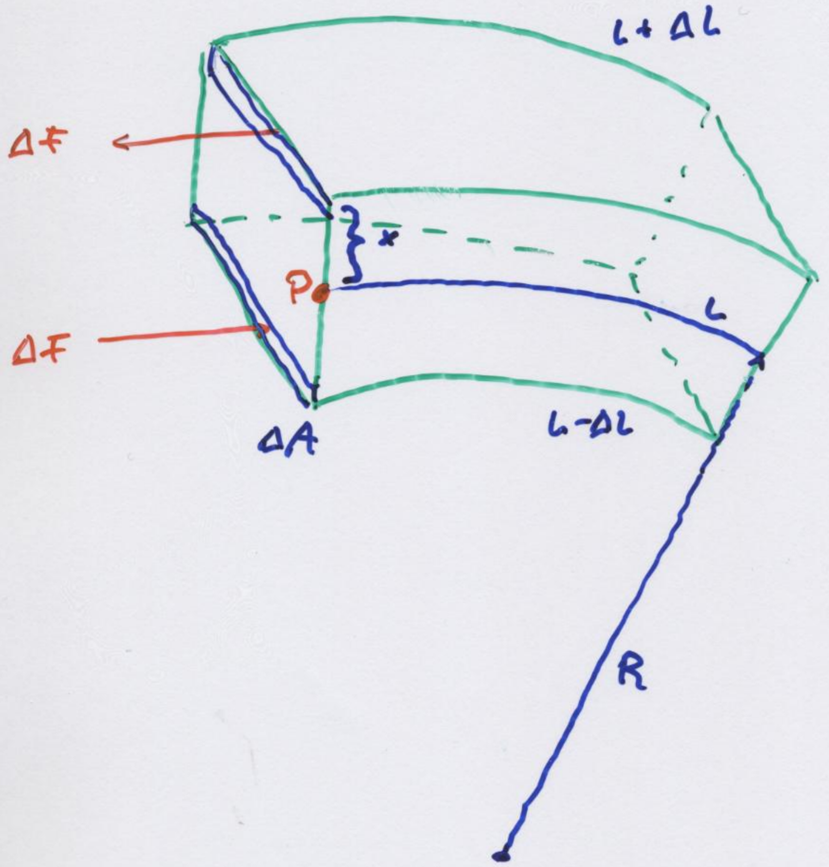
$$\frac{F}{A} = G \cdot \frac{\Delta L}{L}$$

$$= G \cdot \tan\alpha$$

$$\approx G \cdot \alpha$$

Schermodul, Schubmodul

Anwendung: Biegung



Drehmoment $\Delta M = \Delta F \cdot x$

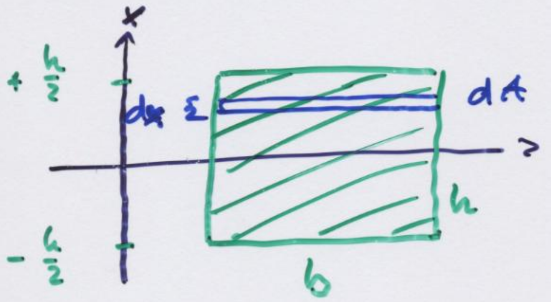
Verwende: $\dfrac{\Delta F}{\Delta A} = E \cdot \dfrac{\Delta L}{L}$, $\dfrac{\Delta L}{L} = \dfrac{x}{R}$

$$\Rightarrow \Delta M = E \cdot \Delta A \cdot \frac{x}{R} \cdot x$$

$$M = \int dM = \frac{E}{R} \cdot \underbrace{\int x^2 \, dA}_{\text{Flächenträgheitsmom.}}$$

Beispiele

A) Rechteckiger Stab



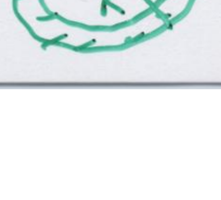
$$dA = b \cdot dx$$

$$I = \int_{-\frac{h}{2}}^{+\frac{h}{2}} x^2 \, b \cdot dx = \frac{h^3}{12} \cdot b$$

B) Zylinder

$$I = \frac{\pi}{4} R^4$$

C) Rohr



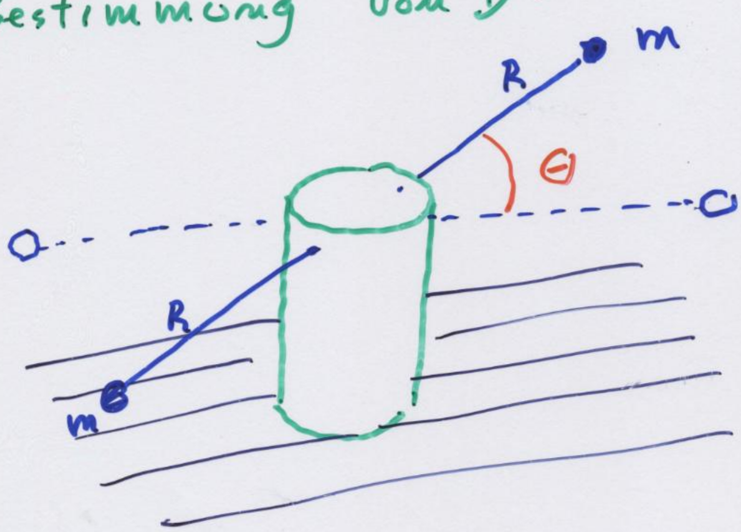
$$I = \frac{\pi}{4}(R^4 - r^4)$$

$$M = D \cdot \theta$$

↑

Torsionsmodul

Bestimmung von D:



Drehmoment $M = D \cdot \theta$

$= J \cdot \ddot{\theta}$

↑

Trägheitsmoment,

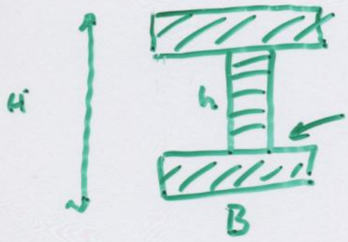
hier $J = 2 m R^2$

$$\theta(t) = \theta_0 \cdot \cos(\omega t + \phi)$$

$$\rightarrow \omega = \sqrt{\frac{D}{J}}$$

Aus Messung von T: $D = \frac{4\pi^2}{T^2} \cdot J$

d) Doppel - T - Träger



$$I = \frac{1}{2}\left(B H^3 - b h^3\right)$$

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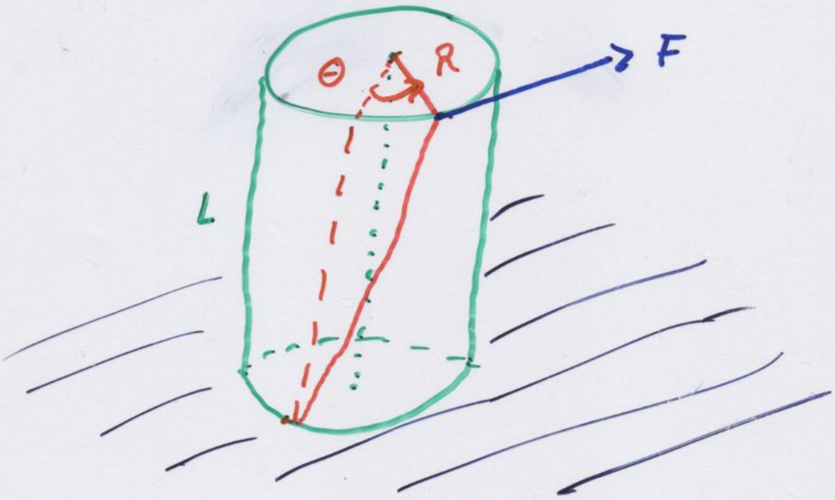
e] Torsion



Drehmoment : $M = R \cdot F$

$$= \frac{R^4}{L} \cdot \frac{\pi}{2} \cdot G \cdot \Theta$$