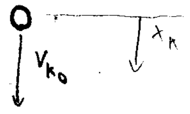
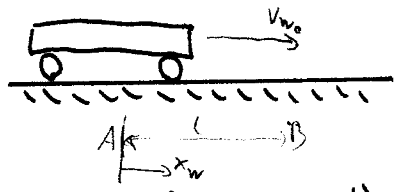


geg.: L, h, v_{W_0} (v_{W_0} = const)

ges.: v_{K_0}



$a_W = 0$ (da v_W const)

$a_K = g = 9{,}81 \frac{m}{s^2}$ (wg. freiem Fall)

$$v_K = \int_0^t g \, dt = g \cdot t + C \Big|_0^t \qquad C = v_{K_0}$$

$$v_K = g \cdot t + v_{K_0}$$

$$x_W = v_{W_0} \cdot t + x_{W_0} \qquad (x_W(t=0) = 0 \rightarrow x_{W_0} = 0$$

$$\boxed{x_W = v_{W_0} \cdot t}$$

$$x_K = \int_0^t v_K \, dt = \int_0^t g \cdot t + v_{K_0} \, dt = \frac{g t^2}{2} + v_{K_0} \cdot t + x_{K_0} \quad \Big| \; x_K(t=0) = 0 \rightarrow x_{K_0} = 0$$

$$\boxed{x_K = \frac{g \cdot t^2}{2} + v_{K_0} t}$$

<u>Bedingung:</u>

$L = x_W(T) \qquad x_K(T) = h$

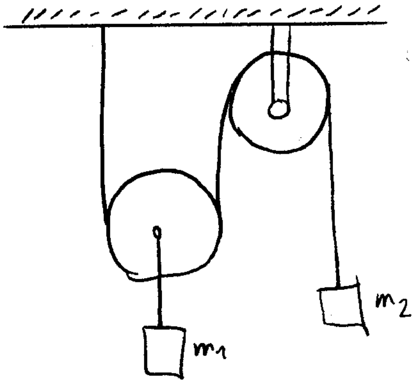
$L = v_{W_0} T \qquad h = \frac{g \cdot T^2}{2} + v_{K_0} \cdot T$

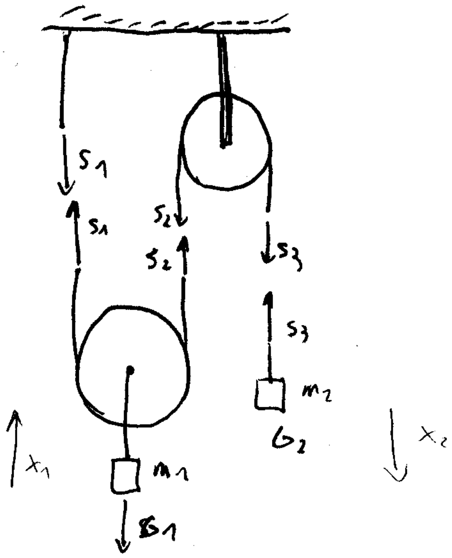
$\rightsquigarrow T = \frac{L}{v_{W_0}}$

$$\Rightarrow h = \frac{g \cdot \left(\frac{L}{v_{W_0}}\right)^2}{2} + v_{K_0} \cdot \frac{L}{v_{W_0}} = \frac{g \cdot L^2}{2 v_{W_0}^2} + \frac{v_{K_0} \cdot L}{v_{W_0}}$$

$$v_{K_0} = \left(h - \frac{g \cdot L^2}{2 v_W^2}\right) \cdot \frac{v_{W_0}}{L} = \frac{h v_W}{L} - \frac{g \cdot L}{2 v_W} = \frac{v_W \cdot h}{L} \left(1 - \frac{g \cdot L^2}{2 v_W^2 h}\right)$$

Beispiel aus Kap. 4





Rolle 1: $m_1 \cdot \ddot{x}_1 = S_1 + S_2 - m_1 \cdot g$

Masse 2: $m_2 \cdot \ddot{x}_2 = m_2 \cdot g - S_3$

$$S_1 = S_2 = S_3 = S$$

Flaschenzug: $x_1 = \frac{1}{2} x_2 \quad \Leftrightarrow \quad x_2 = 2x_1$

$$\begin{array}{ll} \text{I} & m_1 \cdot \ddot{x}_1 = 2S - m_1 \cdot g \\ 2\cdot\text{II} & 2m_2 \cdot \ddot{x}_2 = 2m_2 \cdot g - 2S \end{array}$$

$$m_1 \cdot \ddot{x}_1 + 2m_2 \cdot \ddot{x}_2 = -m_1 g + 2m_2 \cdot g \qquad x_2 = 2x_1$$

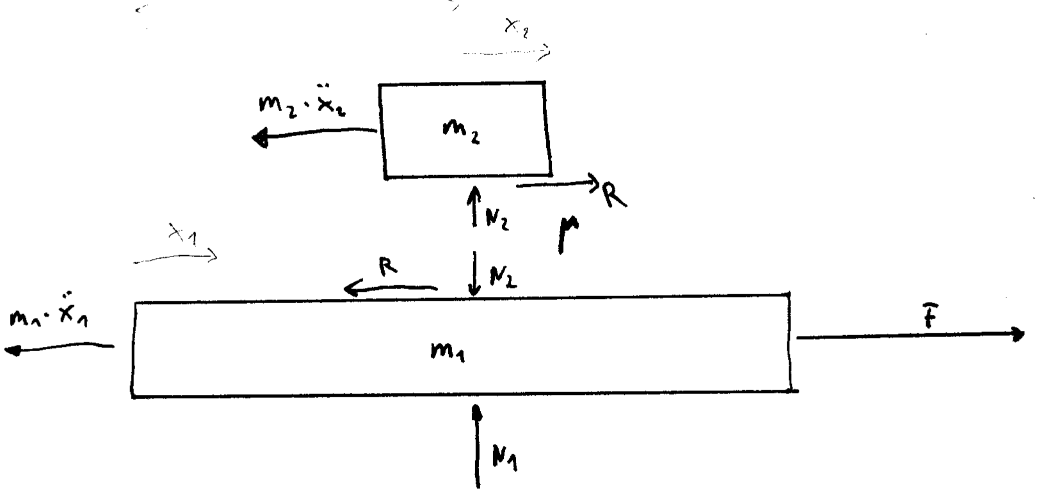
$$m_1 \cdot \ddot{x}_1 + 2m_2 \cdot 2\ddot{x}_1 = -m_1 g + 2m_2 g$$

$$(m_1 + 4m_2)\ddot{x}_1 = (2m_2 - m_1) g$$

$$x_1 = \frac{2m_2 - m_1}{m_1 + 4m_2} g$$

$$\text{II} \Rightarrow \quad S = -m_2 \cdot \ddot{x}_2 + m_2 \cdot g$$

$$S = -m_2 \cdot 2 \frac{m_2 - m_1}{m_1 + 4m_2} g + m_2 g = m_2 g \left(-2 \frac{m_2 - m_1}{m_1 + 4m_2} + 1 \right)$$



① $F - R - m_1 \cdot \ddot{x}_1 = 0$

② $R - m_2 \cdot \ddot{x} = 0$

③ $R = N_2 \cdot \mu = m_2 \cdot g \cdot \mu$

③ in ① ∧ ②

(1a) $F - m_2 \cdot g \cdot \mu - m_1 \cdot \ddot{x}_1 = 0 \quad \leadsto \quad m_1 \cdot \ddot{x} = F - m_2 \cdot g \cdot \mu \quad \leadsto \quad \ddot{x}_1 = \frac{F - m_2 \cdot g \cdot \mu}{m_1}$

(2a) $m_2 \cdot g \cdot \mu - m_2 \cdot \ddot{x}_2 = 0 \quad \leadsto \quad m_2 \cdot \ddot{x}_2 = m_2 \cdot g \cdot \mu \quad \leadsto \quad \ddot{x}_2 = g \cdot \mu$

$$\dot{x}_1 = \int \ddot{x}_1 \, dt = \frac{F_1 - m_2 \cdot g \cdot \mu}{m_1} t + \cancelto{0}{\dot{x}_{10}}$$

$$\dot{x}_2 = \int \ddot{x}_2 dt = g \cdot \mu \cdot t + \cancelto{0}{\dot{x}_{20}}$$

$$x_1 = \int \dot{x}_1 dt = \frac{F_1 - m_2 \cdot g \cdot \mu}{2 m_1} t^2 + \cancelto{0}{x_{10}}$$

$$x_2 = \int \dot{x}_2 \, dt = \frac{g \cdot \mu t^2}{2} + \cancelto{0}{x_{20}}$$

Fällt runter wenn $x_1 = L + x_2$

$$\Rightarrow \quad \frac{F_1 - m_2 \cdot g \cdot \mu}{2 m_1} t^2 = L + \frac{g \cdot \mu \cdot t^2}{2}$$

$$\frac{F_1 - m_2 \cdot g \cdot \mu}{2 m_1} t^2 - \frac{g \cdot \mu \cdot t^2}{2} = L$$

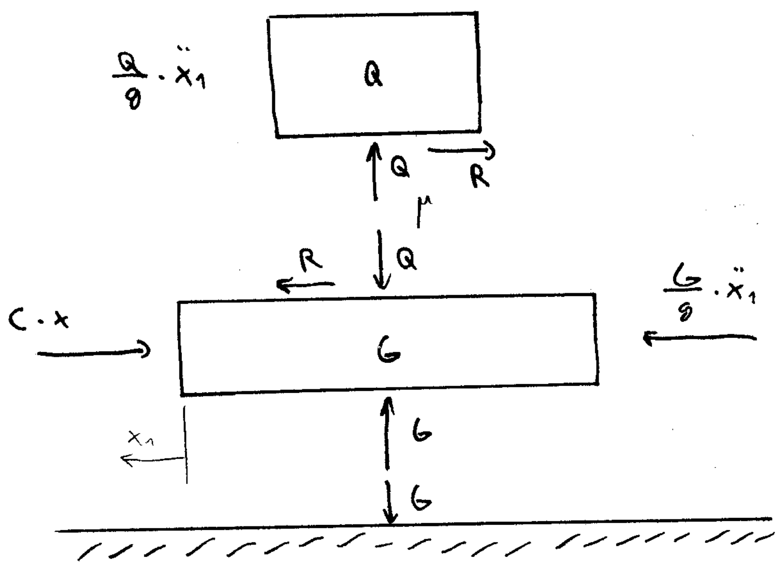
$$\left(\frac{F_1 - m_2 \cdot g \cdot \mu}{2 m_1} - \frac{g \cdot \mu}{2}\right) t^2 = l$$

$$t = \sqrt{\frac{l}{\frac{F_1}{2m_1} - \frac{m_2 \cdot g \cdot \mu}{2m_1} - \frac{g \cdot \mu \cdot m_1}{2\,m_1}}}$$

$$t = \sqrt{\frac{2 l m_1}{F_1 - (m_2 g \mu + g \mu m_1)}}$$

$$t = \sqrt{\frac{2 l m_1}{F - \mu \cdot g\,(m_2 + m_1)}}$$

4.2



Q und G hier als Gewichtskräfte

Körper G : ① $-cx + R + \frac{G}{g} \cdot \ddot{x} = 0$

Körper Q : ② $\frac{Q}{g} \cdot \ddot{x} - R = 0$

Reibung : ③ $R = Q \cdot \mu$

③ in ① und ②

1a $-cx + Q \cdot \mu + \frac{G}{g}\ddot{x} = 0$

2a $\frac{Q}{g} \cdot \ddot{x} - Q \cdot \mu = 0$

$$\ddot{x} = \frac{Q \cdot \mu \cdot g}{Q}$$

② a in ① a

$$-c\cdot x + Q\mu + \frac{G}{g}\cdot\mu\cdot g = 0$$

$$Q\cdot\mu + G\cdot\mu = c\cdot x$$

$$\mu\cdot(G+Q) = c\cdot x$$

$$x = \frac{\mu\cdot(G+Q)}{c}$$

Energiesatz: $E_{kin} = E_{Feder}$

$$\frac{1}{2}mv^2 = \frac{1}{2}cx^2$$

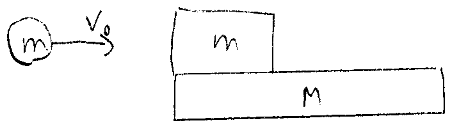
$$mv^2 = cx^2 \qquad \Big| m = \frac{G+Q}{g}$$

$$v^2 = \frac{c\cdot g}{G+Q}\cdot\left[\frac{\mu\cdot(G+Q)}{c}\right]^2$$

$$v^2 = g\cdot\frac{G+Q}{c}\cdot\mu^2$$

$$v = \mu\cdot\sqrt{\frac{g\cdot(G+Q)}{c}}$$

4.)



geg.: $v_1 = v_0 \quad (e=1)$

$v_2 = 0$

ges.: $w_1 = ?$

$w_2 = ?$

Impulssatz: $m_1\cdot v_0 + m_2\cdot v_2 = w_1\cdot m_1 + w_2\cdot m_2 \qquad \Big| \begin{array}{l} m_1 = m_2 = m \\ v_2 = 0 \end{array}$

$$m\cdot v_0 = m(w_1 + w_2)$$

$$v_0 = w_1 + w_2$$

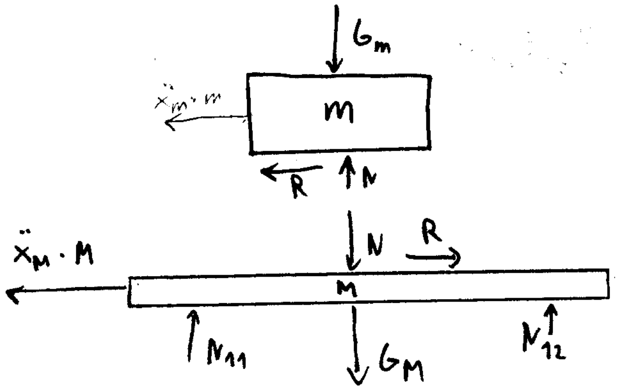
$$w_1 = v_0 - w_2$$

Stoßzahl: $$e = 1 = \frac{w_2 - \overbrace{(v_0 - w_2)}^{w_1}}{v_0}$$

$$1 = \frac{w_2 - v_0 + w_2}{v_0} = \frac{2w_2 - v_0}{v_0} = \frac{v_0}{v_0}\left(\frac{2w_2}{v_0} - 1\right)$$

$$2 = \frac{2w_2}{v_0}$$

$$v_0 = w_2 \implies v_0 = w_1 + v_0 \implies w_1 = 0$$



Klotz: ① $-\ddot{x}_m \cdot m - R = 0 \quad \Leftrightarrow \quad \ddot{x}_m = -\frac{R}{m} = -\frac{\mu \cdot g \cdot m}{m} = -\mu \cdot g$

Brett: ② $-\ddot{x}_M \cdot M + R = 0 \quad \Leftrightarrow \quad \ddot{x}_M = \frac{R}{M} = \frac{m \cdot g \cdot \mu}{M}$

③ $R = m \cdot g \cdot \mu$

$$\dot{x}_m = \int \ddot{x}_m \, dt = -\mu \cdot g \cdot t + \dot{x}_{m0} = -\mu \cdot g \cdot t + v_0 \qquad \Big| \, \dot{x}_{m0} = v_0$$

$$\dot{x}_M = \int \ddot{x}_M \, dt = \mu \cdot g \cdot \frac{m}{M} \cdot t + \cancelto{0}{\dot{x}_{M0}}$$

Ende des Rutschens bei $\dot{x}_m(t_x) = \dot{x}_M(t_x)$

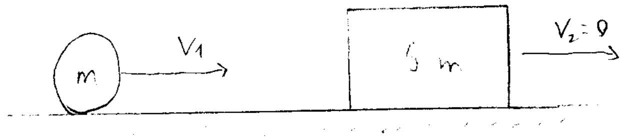
$$-\mu \cdot g \cdot t_x + v_0 = \mu \cdot g \cdot \frac{m}{M} \cdot t_x$$

$$v_0 = \mu \cdot g \cdot \frac{m}{M} \cdot t_x + \mu \cdot g \cdot t_x$$

$$v_0 = \mu \cdot g \cdot t_x \left(\frac{m}{M} + 1 \right)$$

$$t_x = \frac{v_0}{\mu \cdot g \left(\frac{m}{M} + 1 \right)} = \frac{v_0 \cdot M}{\mu \cdot g \cdot (m + M)}$$

$$\dot{x}_M(t_x) = \mu \cdot g \cdot \frac{m}{M} \cdot t_x = \mu \cdot g \cdot \frac{m}{M} \cdot \frac{v_0 \cdot M}{\mu \cdot g (m + M)} = \frac{m \cdot v_0}{m + M}$$



① $m \cdot v_1 + M \cdot v_2 = m \cdot w_1 + M \cdot w_2$

$m \cdot v_1 = m \cdot w_1 + 5m \cdot w_2$

② $e = \dfrac{w_2 - w_1}{v_1 - \cancel{v_2}^{\,0}} \quad \rightsquigarrow \quad w_2 = e \cdot v_1 + w_1$

② in ① $\quad m \cdot v_1 = m \cdot w_1 + 5m(e\, v_1 + w_1)$

$v_1 = w_1 + 5(e v_1 + w_1)$

$v_1 = 5 e v_1 + 6 w_1$

$w_1 = \dfrac{v_1 - 5 e v_1}{6} = \underline{\underline{\left(\dfrac{1-5e}{6}\right) v_1}}$

$w_2 = e \cdot v_1 + \dfrac{v_1 - 5 e v_1}{6} = v_1\left(e + \dfrac{1}{6} - \dfrac{5}{6} e\right)$

$= v_1\left(\dfrac{1}{6} + \dfrac{1}{6} e\right)$

$w_2 = v_1 \cdot \dfrac{1+e}{6}$

Energiesatz

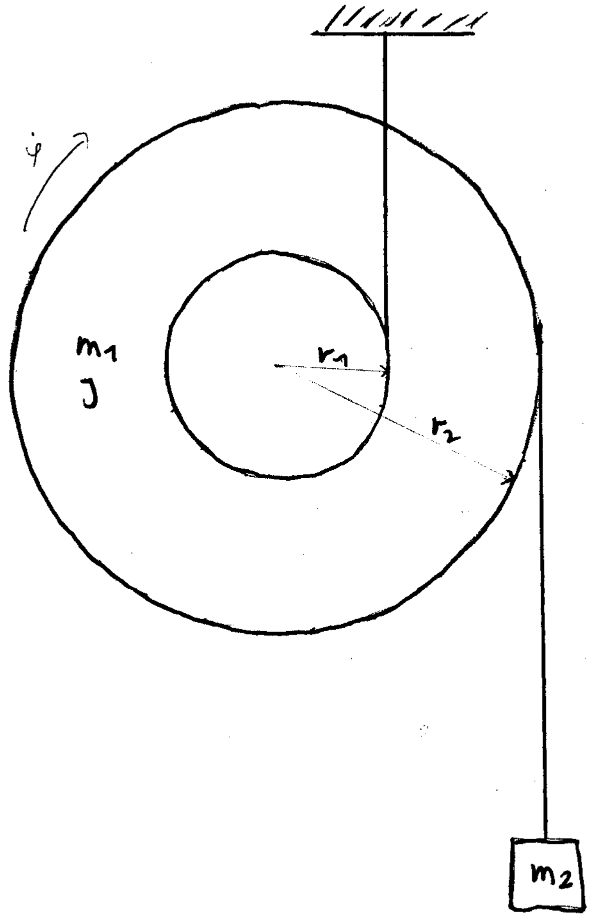
$\dfrac{1}{2} 5m \cdot (w_2^2 - v_2^2) = R \cdot s$

$\dfrac{5}{2} w_2^2 m = 5 m \cdot g \cdot \mu \cdot s$

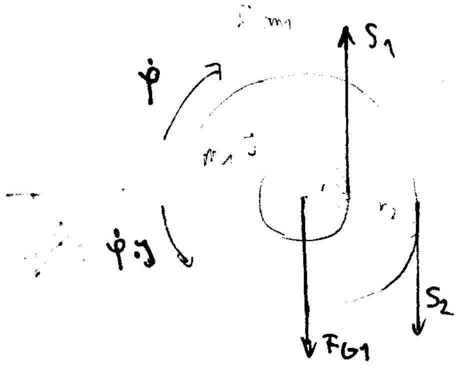
$s = \dfrac{5\, w_2^2}{2 \cdot 5 \quad g \mu} = \dfrac{w_2^2}{2 \quad g \mu}$

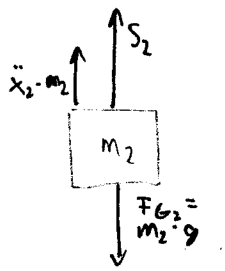
$s = \dfrac{\left(v_1 \cdot \frac{1+e}{6}\right)^2}{2 \quad g \mu} = \dfrac{v_1^2 \cdot \quad 1+e^2}{2 \cdot \quad g \cdot \mu \cdot 36} = \underline{\underline{\dfrac{1+e^2}{72 \mu g}}}$

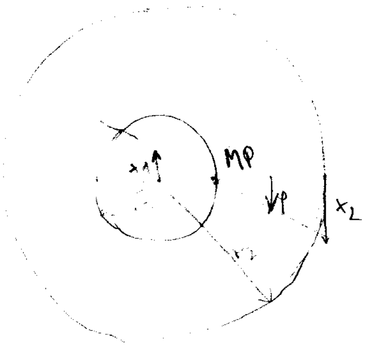
Beispiel aus Kap. 5



Schneiden







① $m_1 \cdot \ddot{x}_1 + S_1 - S_2 - m_1 \cdot g = 0$

② $\ddot{\varphi} \cdot J + S_1 \cdot r_1 - S_2 \cdot r_2 = 0$

③ $m_2 \cdot \ddot{x}_2 + S_2 - m_2 \cdot g = 0$

④ $\dot{x}_1 = - r_1 \cdot \dot{\varphi} \quad \Rightarrow \quad \ddot{x}_1 = -\ddot{\varphi} \cdot r_1$

⑤ $\dot{x}_2 = \dot{\varphi}(r_2 - r_1) \quad \Rightarrow \quad \ddot{x}_2 = \ddot{\varphi} \cdot (r_2 - r_1)$

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4 in 1 $\wedge$ 5 in 3

(1a) $-m_1 \cdot \ddot{\varphi} \cdot r_1 + S_1 - S_2 - m_1 \cdot g = 0$

(2a) $\ddot{\varphi} \cdot J + S_1 \cdot r_1 - S_2 \cdot r_2 = 0$

(3a) $m_2 \cdot \ddot{\varphi}(r_2 - r_1) + S_2 - m_2 \cdot g = 0 \quad \Leftrightarrow \quad S_2 = m_2 \cdot g - m_2 \cdot \ddot{\varphi}(r_2 - r_1)$

3a in 1a $\wedge$ 3a in 2a

(1b) $-\ddot{\varphi} \cdot m_1 \cdot r_1 + S_1 - \left(m_2 \cdot g - m_2 \cdot \ddot{\varphi}(r_2 - r_1)\right) - m_1 \cdot g = 0$

(2b) $\ddot{\varphi} \cdot J + S_1 \cdot r_1 - \left(m_2 \cdot g - m_2 \cdot \ddot{\varphi}(r_2 - r_1)\right) \cdot r_2 = 0$

$$S_1 = \frac{\left[m_2 \cdot g - m_2 \cdot \ddot{\varphi}(r_2 - r_1)\right] \cdot r_2 - \ddot{\varphi} \cdot J}{r_1}$$

$$S_1 = \frac{m_2 \cdot g \cdot r_2}{r_1} - \frac{m_2 \cdot \ddot{\varphi} \cdot (r_2 - r_1) \cdot r_2}{r_1} - \frac{\ddot{\varphi} \cdot J}{r_1}$$

2b in 1b

$$-\ddot{\varphi} \cdot m_1 \cdot r_1 + \frac{m_2 \cdot g \cdot r_2}{r_1} - \frac{m_2 \cdot \ddot{\varphi}(r_2 - r_1) \cdot r_2}{r_1} - \frac{\ddot{\varphi} \cdot J}{r_1} - m_2 \cdot g + \cdot \ddot{\varphi}(r_2 - r - m_1 \cdot g = 0$$

$$\ddot{\varphi}\left[-m_1 \cdot r_1 - \frac{m_2 (r_2 - r_1) \cdot r_2}{r_1} - \frac{J}{r_1} + m_2 \cdot (r_2 - r_1)\right] = m_1 \cdot g - \frac{m_2 \cdot g \cdot r_2}{r_1} + m_2 \cdot g$$

$$\ddot{\varphi} = g \cdot \frac{m_1 - m_2 \cdot \frac{r_2}{r_1} + m_2}{-m_1 \cdot r_1 - \frac{m_2 (r_2 - r_1) \cdot r_2}{r_1} - \frac{J}{r_1} + m_2 (r_2 - r_1)} \cdot \left(\frac{r_1}{r_1}\right)$$

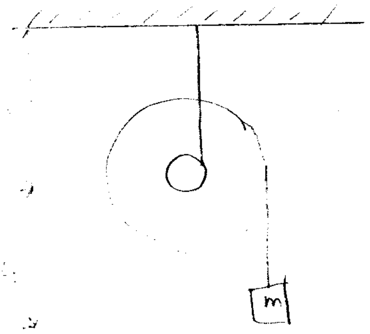
$$\ddot{\varphi} = g \cdot \frac{m_1 \cdot r_1 - m_2 \cdot r_2 + m_2 \cdot r_1}{-m_1 \cdot r_1^2 - m_2 (r_2 - r_1) r_2 - J + m_2 \cdot (r_2 - r_1) \cdot r_1} = g \frac{m_1 \cdot r_1 - m_2 (r_2 + r_1)}{-m_1 \cdot r_1^2 - m_2 \cdot r_2^2 + m_2 r_1 r_2 - J + m_2 r_2 r_1 - m_2 r_1^2}$$

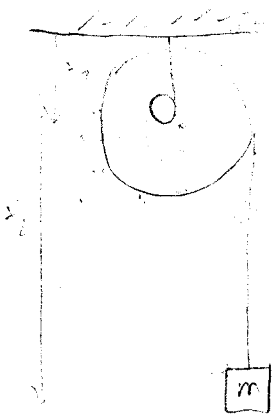
$$\ddot{\varphi} = g \cdot \frac{m_2 (r_2 + r_1) - m_1 r_1}{m_1 \cdot r_1^2 + m_2 \cdot r_2^2 - m_2 r_1 r_2 + J - m_2 r_2 r_1 + m_2 r_1^2}$$ (erweitert mit -1)

$$= m_2 (r_2 - r_1)^2$$

$$\ddot{\varphi} = g \cdot \frac{m_2 (r_2 + r_1) - m_1 r_1}{m_1 r_1^2 + m_2 (r_2 - r_1)^2 + J}$$

Aufgabe von vorheriger Seite mit Energieerhaltungssatz





$$E_{pot\,1} = -m_1 \cdot g \cdot L_1 - m_2 \cdot g \cdot (L_1 + L_2)$$

$$E_{pot\,2} = -m_1 \cdot g \cdot x_1 - m_2 \cdot g \cdot x_2$$

$$E_{kin\,1} = 0$$

$$E_{kin\,2} = \frac{1}{2} m_1 \dot{x}_1^2 + \frac{1}{2} m_2 \dot{x}^2 + \frac{1}{2} J \dot{\varphi}^2$$

$$\left| \begin{array}{l} x_1 = -r_1 \cdot \dot{\varphi} \\ x_2 = (r_2 - r_1)\dot{\varphi} \end{array} \right.$$

$$E_{pot\,1} + E_{kin\,1} = E_{pot\,2} + E_{kin\,2}$$

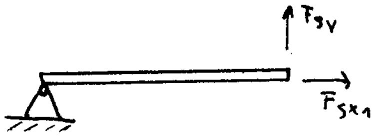
$$-m_1 \cdot g \cdot L_1 - m_2 \cdot g \cdot (L_1 + L_2) = -m_1 \cdot g \cdot x_1 - m_2 \cdot g \cdot x_2 + \frac{1}{2}\left(m_1 \cdot \dot{x}_1^2 + m_2 \cdot \dot{x}^2 + J \dot{\varphi}^2\right)$$

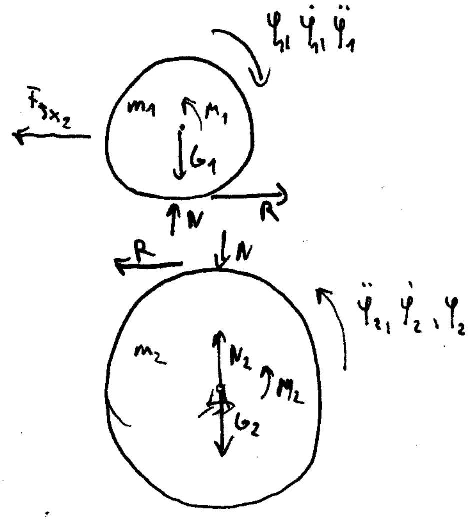
$$-m_1 \cdot g \cdot L_1 - m_2 \cdot g (L_1 + L_2) = m_1 \cdot g \cdot r_1 \cdot \varphi - m_2 \cdot g \cdot (r_2 - r_1) \varphi + \frac{\dot{\varphi}^2}{2}\left[\frac{m_1 \cdot r_1^2 + m_2 \cdot (r_2 - r_1)^2 + J}{1}\right]$$

$$\frac{\dot{\varphi}^2}{2} = \frac{g \cdot [-m_1 \cdot L_1 - m_2 (L_1 + L_2)] - \varphi g (m_1 \cdot r_1 - m_2 (r_2 - r_1))}{m_1 \cdot r_1^2 + m_2 (r_2 - r_1)^2 + J}$$

mit $L_1 = 0$ und $L_2 = 0$:

$$\frac{\dot{\varphi}^2}{2} = \varphi \cdot \frac{g \cdot m_2 (r_2 - r_1) - g \cdot m_1 \cdot r_1}{m_1 \cdot r_1^2 + m_2 (r_2 - r_1)^2 + J}$$





$F_{Sy} = 0$

$F_{Sx_1} - F_{Sx_2} = 0$

1) $N_1 = m_1 \cdot g$

2) $R = \mu \cdot N_1$

3) $M_1 = R \cdot r_1$

4) $M_2 = R \cdot r_2$

5) $M_1 = -J_1 \cdot \ddot{\varphi}_1 \quad \rightsquigarrow \quad \ddot{\varphi}_1 = -\frac{M_1}{J_1} \qquad \dot{\varphi}_1 = -\frac{M_1}{J_1} t + \dot{\varphi}_{10}$

6) $M_2 = J_2 \cdot \ddot{\varphi}_2 \quad \rightsquigarrow \quad \ddot{\varphi}_2 = \frac{M_2}{J_2} \qquad \dot{\varphi}_2 = \frac{M_2}{J_2} \cdot t + \cancel{\dot{\varphi}_{20}}^{\,0}$

---

1 in 2 , 3 in 5 , 4 in 6

2a) $R = m_1 \cdot g \cdot \mu$

5a) $\dot{\varphi}_1 = -\frac{R \cdot r_1}{J_1} t + \dot{\varphi}_{10}$

6a) $\dot{\varphi}_2 = \frac{R \cdot r_2}{J_2} \cdot t$

2a in 5a und 6a

5b) $\dot{\varphi}_1 = -\frac{m_1 \cdot g \cdot \mu \cdot r_1 \cdot t}{J_1} + \dot{\varphi}_{10} = -\frac{2\cancel{m_1} \cdot g \cdot \mu \cdot \cancel{r_1} \cdot t}{\cancel{m_1} \cdot r_1^{\cancel{2}}} + \dot{\varphi}_{10}$

6b) $\dot{\varphi}_2 = \frac{m_1 \cdot g \cdot \mu \cdot r_2 \cdot t}{J_2} = \frac{2 m_1 \cdot g \cdot \mu \cdot \cancel{r_2} \cdot t}{m_2 \cdot r_2^{\cancel{2}}}$

Bedingung: $\dot{\varphi}_1 \cdot r_1 = \dot{\varphi}_2 \cdot r_2$ bei $t = t_x$

$\dot{\varphi}_{10} \cdot r_1 - 2 g \mu t_x = \frac{2 m_1 g \mu t_x}{m_2}$

$$\frac{r\cdot\dot{\varphi}_{10}}{t_*} = \frac{2\mu g m_1}{m_2} + 2\mu g = 2\mu g\left(\frac{m_1}{m_2}+1\right)$$

$$\underline{\underline{t_* = \frac{r_1\cdot\dot{\varphi}_{10}}{2\mu g\left(\frac{m_1}{m_2}+1\right)}}}$$

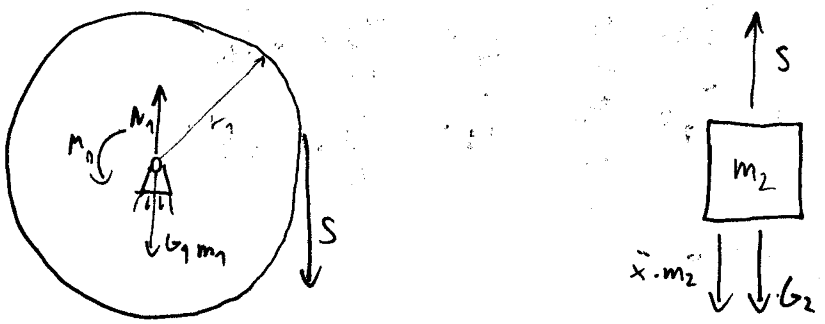
t_* einset , in $\dot{\varphi}_1$ und $\dot{\varphi}_2$

$$\dot{\varphi}_1 = -\frac{2\mu g}{r_1}\cdot\frac{r_1\,\dot{\varphi}_{10}}{2\mu g\left(\frac{m_1}{m_2}+1\right)} + \dot{\varphi}_{10} = \dot{\varphi}_{10} - \frac{\dot{\varphi}_{10}}{\frac{m_1}{m_2}+1}$$

$$\dot{\varphi}_2 = \frac{2\mu g m_1}{r_2\, m_2}\cdot\frac{r_1\,\dot{\varphi}_{10}}{2\mu g\left(\frac{m_1}{m_2}+1\right)} = \frac{m_1\cdot r_1\cdot\dot{\varphi}_{10}}{r_2\, m_2\left(\frac{m_1}{m_2}+1\right)}$$

---

c)



1) $G_2 = m_2\cdot g$
2) $S - G_2 - \ddot{x}\cdot m_2 = 0$
3) $\ddot{\varphi}\cdot r = \ddot{x} \quad \curvearrowright \ddot{\varphi} = \frac{\ddot{x}}{r}$
4) $M_0 - S\cdot r_1 = J\cdot\ddot{\varphi}$
5) $J = \frac{1}{2} m_1 r^2$

---

1 in 2 3 in 4 5 in 4

2a) $S - m_2 g - \ddot{x}\cdot m_2 = 0 \quad \curvearrowright S = m_2 g + \ddot{x}\cdot m_2 \Rightarrow S = m_2(g+a) \quad |\ddot{x}=a$

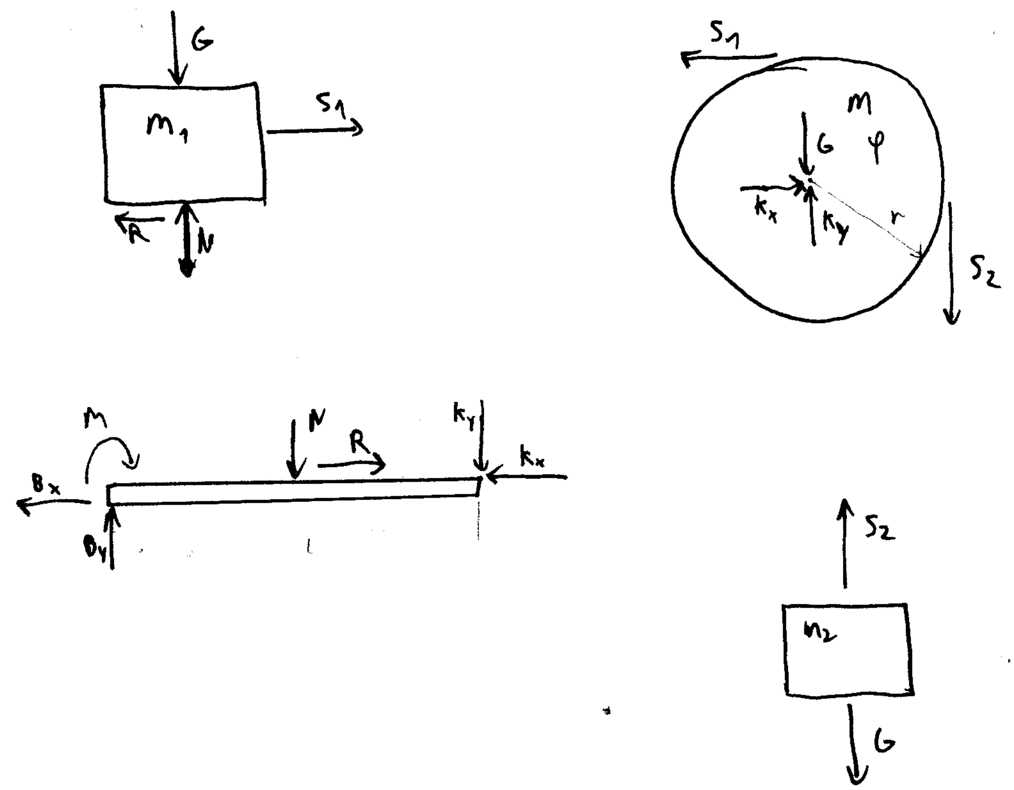
4a) $M_0 - S\cdot r_1 = \frac{1}{2} m_1 r^2\cdot\frac{\ddot{x}}{r}$

2a in 4a

4b) $M_0 - m_2(g+a)\cdot r = \frac{1}{2} m_1 r^{\cancel{2}}\cdot\frac{a}{\cancel{r}}$

$M_0 = \frac{m_1}{2}\cdot a + m_2\cdot r\cdot(g+a)$

5.4



1) $\ddot{x}_1 \cdot m = S_1 - R$

2) $0 = G - N \quad \leadsto \quad N = G \Rightarrow N = m \cdot g$

3) $\ddot{x}_2 \cdot m = G - S_2$

4) $\ddot{\varphi} \cdot J = r(S_2 - S_1)$

5) $R = \mu \cdot N$

6) $0 = k_y - G - S_2 \quad \leadsto \quad k_y = G + S_2$

7) $0 = k_x - S_1 \quad \leadsto \quad k_x = S_1$

8) $\dot{x}_2 = \dot{\varphi} \cdot r = \dot{x}_1 = \dot{x} \quad \Rightarrow \quad \ddot{\varphi} \cdot r = \ddot{x} \quad \leadsto \quad \ddot{\varphi} = \frac{\ddot{x}}{r}$

2 in 3, 5, 6 , 8 in 1, 3, 4

1a) $\ddot{x} \cdot m = S_1 - R \quad \leadsto \quad S_1 = \ddot{x} m + R$

3a) $\ddot{x} \cdot m = m \cdot g - S_2 \quad \leadsto \quad S_2 = m \cdot g - \ddot{x} m$

4a) $\frac{\ddot{x}}{r} \cdot J = r(S_2 - S_1)$

5a) $R = \mu \cdot m \cdot g$

6a) $0 = k_y - m \cdot g - S_2$

7a) $S_1 = k_x$

5 in 1 dann 1 in 4, 3 $J = \frac{1}{2} m r^2$

$$\frac{\ddot{x}}{r} \frac{1}{2} m r^2 = r(m \cdot g - \ddot{x} m - \ddot{x} m - \mu \cdot m \cdot g)$$

$$\ddot{x} \frac{1}{2} m = m \cdot g - \ddot{x} m - \ddot{x} m - \mu \cdot m \cdot g$$

$$\frac{1}{2} \ddot{x} = g - \ddot{x} - \ddot{x} + \mu \cdot g = g(1-\mu) - 2\ddot{x}$$

$$\ddot{x}\left(\frac{1}{2} + \frac{4}{2}\right) = g(1-\mu) = \frac{5}{2}\ddot{x}$$

$$S_1 = \frac{2}{5} g (1-\mu) \cdot m + m \cdot g \cdot \mu$$

$$S_1 = m \cdot g \left(\frac{2}{5}(1-\mu) + \mu \right)$$

$$S_1 = m \cdot g \left(\frac{2}{5} - \frac{2}{5}\mu + \frac{5}{5}\mu \right)$$

$$S_1 = m \cdot g \ \frac{2+3\mu}{5}$$

$$S_2 = m \cdot g - \ddot{x} \cdot m$$

$$\ddot{x} = \frac{2}{5} g (1-\mu)$$

$$S_2 = m \cdot g - \frac{2}{5} g (1-\mu) m$$

$$S_2 = m \cdot g \left(1 - \frac{2}{5} (1-\mu) \right)$$

$$S_2 = m \cdot g \left(\frac{5}{5} - \frac{2}{5} + \frac{2}{5}\mu \right)$$

$$S_2 = m \cdot g \left(\frac{3+2\mu}{5} \right)$$

$$k_x = S_1 = m \cdot g \frac{2+3\mu}{5}$$

$$k_y = N + S_2 = m \cdot g + m \cdot g \left(\frac{3+2\mu}{5} \right)$$

$$k_y = m \cdot g \left(\frac{8}{5} + \frac{2}{5}\mu \right)$$

$$B_x + k_x - R = 0$$

$$B_x = R - k_x$$

$$B_x = m \cdot g \cdot \mu - m \cdot g \cdot \frac{2+3\mu}{5}$$

$$B_x = m \cdot g \left(\frac{5}{5}\mu - \frac{3}{5}\mu - \frac{2}{5} \right)$$

$$B_x = m \cdot g \left(\frac{2\mu - 2}{5} \right)$$

$$B_x = \frac{2}{5} m \cdot g (\mu - 1)$$

$$B_y = N + k_y$$

$$B_y = m \cdot g + m \cdot g \left(\frac{8+2\mu}{5} \right)$$

$$B_y = m \cdot g \left(1 + \frac{8}{5} + \frac{2}{5}\mu \right)$$

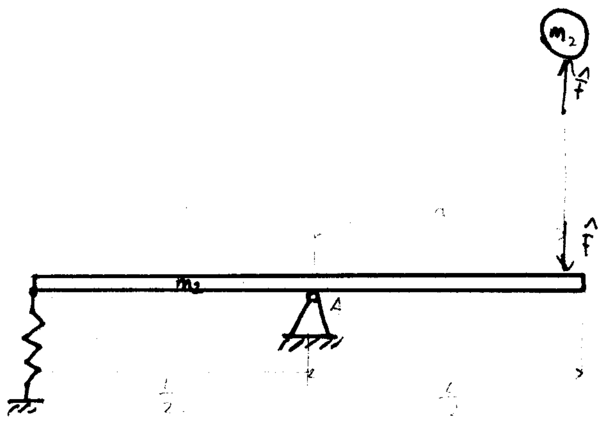
$$B_y = m \cdot g \left(\frac{13+2\mu}{5} \right)$$

$$M + N \cdot x + k_y \cdot L = 0$$

$$M = -N \cdot x - k_y \cdot L$$

$$M = -m \cdot g \cdot x - mg \left(\frac{8}{5} + \frac{2}{5}\mu \right) L$$

$$M = -m \cdot g \left(x + L \frac{8+2\mu}{5} \right)$$



1) $m_1(\dot{x}_{1n} - \dot{x}_{1v}) = -\hat{F}$
2) $J(\dot{\varphi}_n - \dot{\varphi}_v) = a \cdot \hat{F}$
3) $\dot{x}_{2n} - \dot{x}_{1n} = e(\dot{x}_{1v} - \dot{x}_{2v}) = 0 \quad \curvearrowright \dot{x}_2 = \dot{x}_{1n}$
4) $\dot{x}_{2n} = a \cdot \dot{\varphi}$

1a) $m_1(\dot{x}_{1n} - \dot{x}_{1v}) = -\hat{F}$
2a) $\hat{F} = \frac{J \cdot \dot{\varphi}}{a}$
3a) $\dot{x}_{1n} = a \cdot \dot{\varphi}$

$$m_1(a \cdot \dot{\varphi} - \dot{x}_{1v}) = -\frac{J\dot{\varphi}}{a} \qquad | \dot{x}_{1v} = v_0$$

$$m_1 a^2 \dot{\varphi} - a m_1 v_0 + J \cdot \dot{\varphi} = 0$$

$$\dot{\varphi}(m_1 a^2 + J) = a v_0 m_1$$

$$\dot{\varphi} = \frac{a v_0 m_1}{m_1 a^2 + J} = \frac{a v_0 m_1}{m_1 a^2 + \frac{1}{12} m_2 l^2} = \frac{a V_0}{a^2 + \frac{1}{12} \frac{m_2}{m_1} l^2}$$

Energiesatz

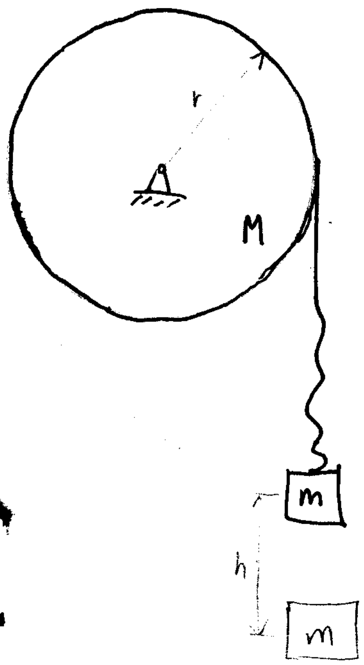
$$m \cdot g \cdot \frac{a}{\frac{L}{2}} \cdot x_{max} + \frac{1}{2} J \dot{\varphi}^2 + \frac{1}{2} m_1 a^2 \dot{\varphi}^2 = \frac{1}{2} c x_{max}^2$$

$$\frac{4 m g a x_{max}}{cL} + \frac{J \dot{\varphi}^2}{c} + \frac{m_1 \cdot a^2 \varphi^2}{c} = x_{max}^2$$

$$0 = x_{max}^2 - \frac{4 m g a x_{max}}{cL} - \frac{\varphi^2}{c}(J + m_1 a^2)$$

$\Rightarrow$ p-q-Formel

5.16



1) $\dot{x}_{mv} = \sqrt{2gh}$

2) $\dot{x}_{MPv} = 0$

3) $\dot{\varphi}_{Mn} \cdot r = \dot{x}_{MPn}$

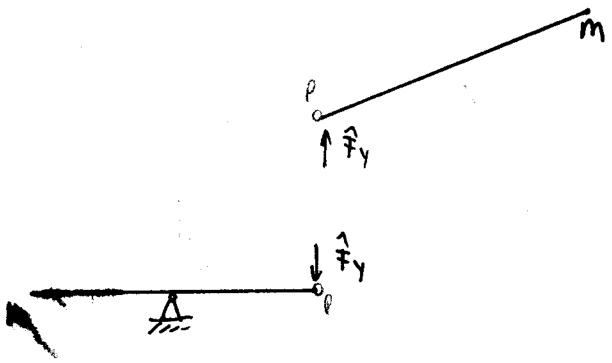
4) $J(\dot{\varphi}_{Mn} - \dot{\varphi}_{MV}) = r \cdot \hat{F}$

5) $m(\dot{x}_{mn} - \dot{x}_{mv}) = -\hat{F}$

6) $e = -\dfrac{\dot{x}_{MPn} - \dot{x}_{mPn}}{\dot{x}_{MPv} - \dot{x}_{mPv}} = 1$

7) $J = \frac{1}{2} M r^2$

5.17



vor Stoß	nach Stoß
$\dot{x}_{1v} = 0$	$\dot{x}_{2n} = ?$
$\dot{y}_{1v} = v_1$	$\dot{y}_{1n} = ?$
$\dot{\varphi}_{1v} = 0$	$\dot{\varphi}_{1n} = ?$
$\dot{x}_{2v} = 0$	$\dot{x}_{2n} = 0$
$\dot{y}_{2v} = 0$	$\dot{y}_{2n} = ?$
$\dot{\varphi}_{2v} = 0$	$\dot{\varphi}_{2n} = ?$

1) $m(\dot{x}_{1n} - \dot{x}_{1v}) = 0$

2) $m(\dot{y}_{1n} - \dot{y}_{1v}) = -\hat{F}_Y$

3) $J(\dot{\varphi}_{1n} - \dot{\varphi}_{1v}) = \hat{F}_Y \cdot l$

4) $m(\dot{x}_{2n} - \dot{x}_{2v}) = 0$

5) $m(\dot{y}_{2n} - \dot{y}_{2v}) = \hat{F}_Y$

6) $J(\dot{\varphi}_{2n} - \dot{\varphi}_{2v}) = \hat{F}_Y \cdot l$

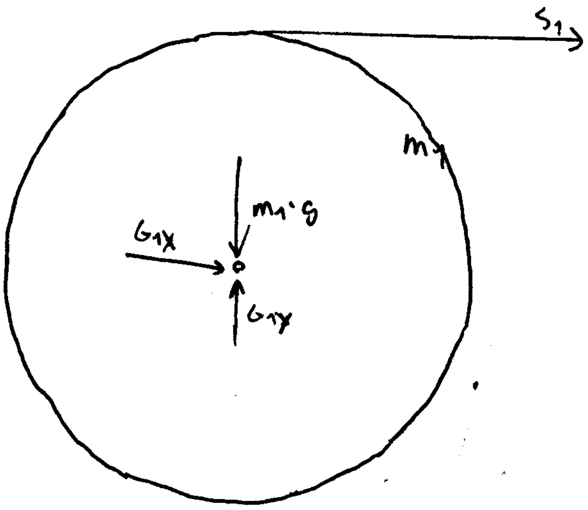
7) $e = 1 = -\dfrac{\dot{y}_{2n} - \dot{y}_{1n}}{\dot{y}_{2v} - \dot{y}_{1v}}$

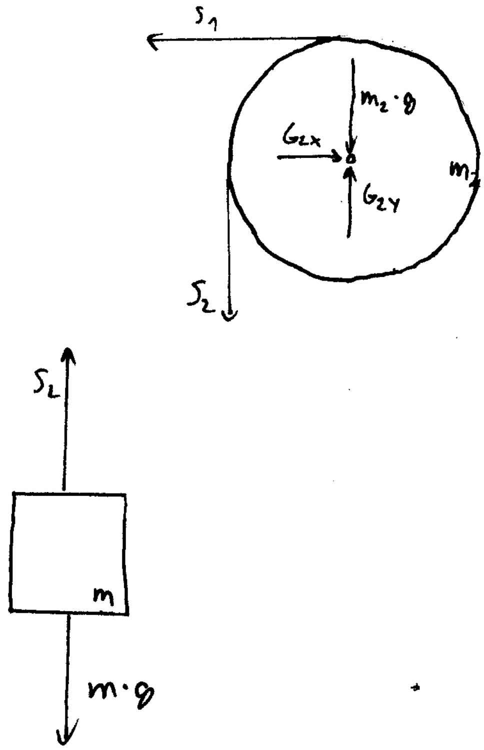
8) $\dot{\varphi}_{1n} \cdot l \cdot \cos\beta = \dot{y}_{n1}$

9) $J = \frac{1}{3} m l^2$

10) $\dot{y}_{2n} = \dot{\varphi}_{2n} \cdot l$

Kunow 2007





$J_1 = \frac{1}{2} m_1 \cdot r^2$

$J_2 = \frac{1}{2} m_2 r^2$

1) $S_1 + G_{1x} = 0$ uninteressant

2) $\cancel{G_{1y} - m_1 \cdot g = 0}$

3) $M_0 - S_1 \cdot r_1 = \ddot{\varphi}_1 \cdot J_1 \quad \Leftrightarrow \quad \frac{M_0 - \ddot{\varphi}_1 \cdot J_1}{r_1} = S_1$

4) $S_1 \cdot r_2 + S_2 \cdot r_2 = J_2 \cdot \ddot{\varphi}_2$

5) $G_{2x} - S_1 = 0$ uninteressant

6) $\cancel{G_{2y} - m_2 \cdot g + S_2 = 0}$

7) $m \cdot g - S_2 = \ddot{x} \cdot m$

8) $\dot{\varphi}_1 \cdot r_1 = \dot{\varphi}_2 \cdot r_2 \quad \rightarrow \ddot{\varphi}_1 \cdot r_1 = \ddot{\varphi}_2 \cdot r_2$

9) $\dot{\varphi}_2 \cdot r_2 = \dot{x} \quad \rightarrow \ddot{\varphi}_2 \cdot r_2 = \ddot{x}$

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3 in 4 (3 nach S_1 umgestellt)

4a) $\frac{M_0 - \ddot{\varphi}_1 \cdot J_1}{r_1} \cdot r_2 + S_2 \cdot r_2 = J_2 \cdot \ddot{\varphi}_2$

7a) $S_2 = m \cdot g - \ddot{x} \cdot m$

8a) $\ddot{\varphi}_2 = \ddot{\varphi}_1 \cdot \frac{r_1}{r_2}$

9a) $\ddot{\varphi}_2 \cdot r_2 = \ddot{x}$

7a in 4a

8a in 9a, 4a

4b) $\frac{M_0 - \ddot{\varphi}_1 \cdot J_1}{r_1} \cdot r_2 + (m \cdot g - \ddot{x} \cdot m) r_2 = J_2 \cdot \ddot{\varphi}_1 \frac{r_1}{r_2}$

9b) $\ddot{\varphi}_1 \cdot \frac{r_1}{r_2} \cdot r_2 = \ddot{x}$

9b in 4b

4b) $\dfrac{M_0 - \ddot{\varphi}_1 J_1}{r_1} \cdot r_2 + (m \cdot g - \ddot{x} m)\, r_2 = J_2 \cdot \ddot{\varphi}_1 \dfrac{r_1}{r_2}$

4c) $\dfrac{M_0 - \ddot{\varphi}_1 \cdot J_1}{r_1} \cdot r_2 + (m \cdot g - m\ddot{\varphi}_1 \cdot r_1)\, r_2 = J_2 \cdot \ddot{\varphi}_1 \cdot \dfrac{r_1}{r_2}$

$$-\frac{r_2 \cdot \ddot{\varphi}_1 \cdot J_1}{r_1} + \frac{M_0}{r_1} \cdot r_2 + m \cdot g \cdot r_2 - m \ddot{\varphi}_1 r_1 \cdot r_2 - J_2 \cdot \ddot{\varphi}_1 \cdot \frac{r_1}{r_2} = 0$$

$$\frac{M_0}{r_1} \cdot r_2 + m g r_2 = \ddot{\varphi}_1 m r_1 r_2 + \ddot{\varphi}_1 J_2 \cdot \frac{r_1}{r_2} + \frac{\ddot{\varphi}_1 \cdot J_1 \cdot r_2}{r_1}$$

$$\frac{M_0}{r_1} \cdot r_2 + m \cdot g \cdot r_2 = \ddot{\varphi}_1 \left(m \cdot r_1 \cdot r_2 + J_2 \cdot \frac{r_1}{r_2} + \frac{J_1 \cdot r_2}{r_1} \right)$$

$$\ddot{\varphi}_1 = \frac{r_2 \left(\frac{M_0}{r_1} + m \cdot g \right)}{m \cdot r_1 r_2 + J_2 \cdot \frac{r_1}{r_2} + J_1 \cdot \frac{r_2}{r_1}}$$

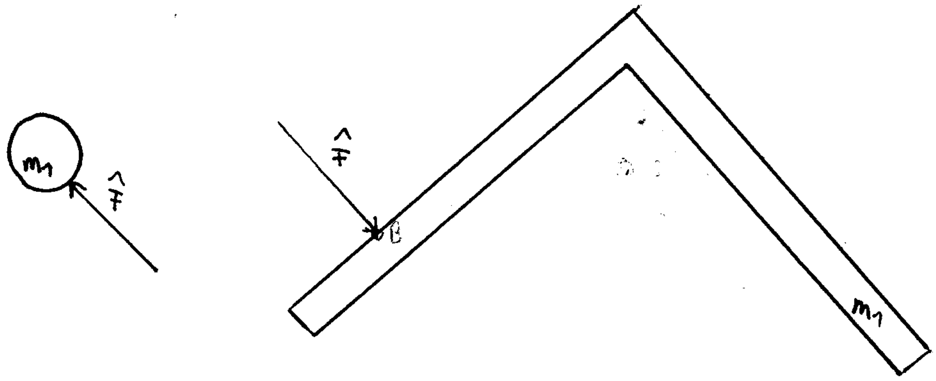
$J_1 = \frac{1}{2} m_1 r_1^2$

$J_2 = \frac{1}{2} m_2 \cdot r_2^2$

$$\ddot{\varphi}_1 = \frac{r_2 \left(\frac{M_0}{r_1} + m \cdot g \right)}{m \cdot r_1 \cdot r_2 + \frac{1}{2} m_2 r_2^2 \cdot \frac{r_1}{r_2} + \frac{1}{2} m_1 r_1^2 \frac{r_2}{r_1}}$$

$$\ddot{\varphi}_1 = \frac{r_2 \left(\frac{M_0}{r_1} + m \cdot g \right)}{r_1 \cdot r_2 \left[m + \frac{1}{2} (m_2 + m_1) \right]}$$

$$\ddot{\varphi}_1 = \frac{\frac{M_0}{r_1} + m \cdot g}{r_1 \left[m + \frac{1}{2}(m_1 + m_2) \right]} = \frac{M_0 + m \cdot g \cdot r_1}{r_1^2 \left[m + \frac{1}{2}(m_1 + m_2) \right]} = \underline{\underline{\frac{2 (M_0 + m \cdot g \cdot r_1)}{r_1^2 (2m + m_1 + m_2)}}}$$



Vor Stoß

$\dot{x}_{1v} = V_0 \cdot \cos 45°$

$\dot{y}_{1v} = V_0 \cdot \sin 45°$

$\dot{x}_{2v} = 0$

$\dot{y}_{2v} = 0$

$\dot{\varphi} = 0$

nach Stoß

$\dot{x}_{1n}, \dot{y}_{1n}, \dot{x}_{2n}, \dot{y}_n \quad \dot{\varphi}_n$

$S\left(\frac{L}{4}; \frac{L}{2}\right)$

$J = \frac{5}{24} m_2 L^2$

1) $m_1 (\dot{x}_{1n} - \dot{x}_{1v}) = -\hat{F}$

2) $m_1 (\dot{y}_{1n} - \dot{y}_{1v}) = 0 \quad \curvearrowright \quad \dot{y}_{1n} = \dot{y}_{1v}$

3) $m_2 (\dot{x}_{2n} - 0) = \hat{F}$

4) $m_2 (\dot{y}_{2n} - 0) = 0 \quad \curvearrowright \quad \dot{y}_{2n} = 0$

5) $J (\dot{\varphi}_n - 0) = -\hat{F} \cdot y_S$

6) $e = -\dfrac{\dot{x}_{1n} - \left(\dot{x}_{2n} - \frac{L}{2}\dot{\varphi}_n\right)}{V_0 \cdot \cos 45° - 0}$

3b in 4b

$$\left(\dot{\varphi}_n \sqrt{2}\, b - \frac{e\, V_0}{\sqrt{2}} - \frac{V_0}{\sqrt{2}}\right) m_1 = - \frac{\dot{\varphi}_n\, m_2\, a^2}{2\, b\, \sqrt{2}}$$

$\vdots$

$$\dot{\varphi}_n = \frac{V_0}{2b} \left(\frac{e+1}{1 + \frac{m_2 a^2}{m_1 4 b^2}} \right)$$