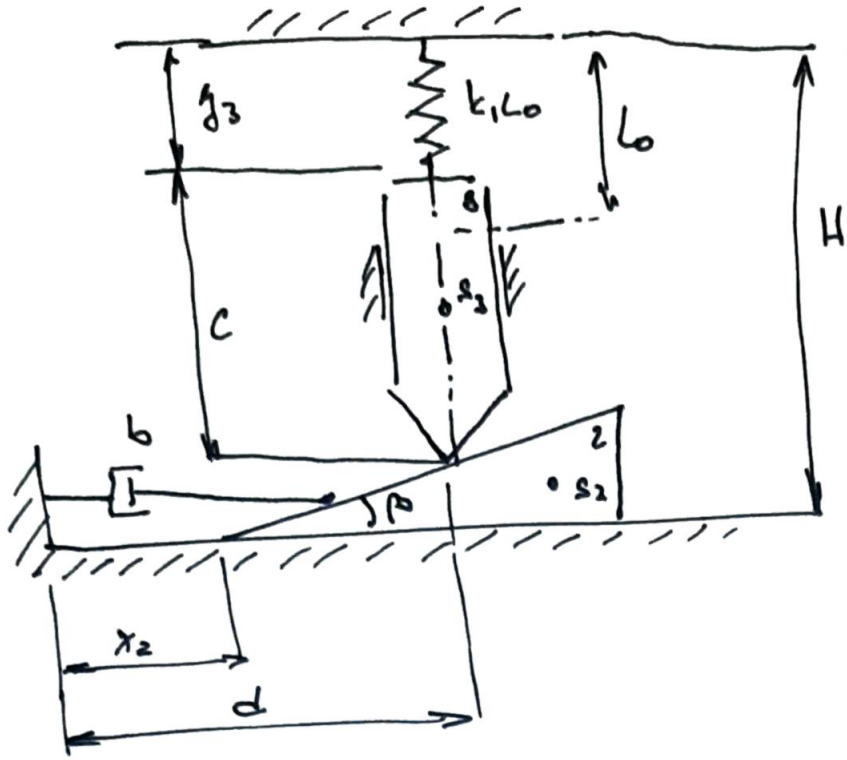


CVIČENÍ - SOUSTAVY TĚLES ①

D: $g, c, d, H, \beta, k_1 l_0, b\left[\frac{N.s}{m}\right]$ bez tření, m_2, m_3 ($F_T = b \cdot v_2$)

U: $f(\ddot{x}_2, \dot{x}_2, x_2, t) = 0$

Redukujeme na hmotu m_{red} na které působí síla Q a jejíž souřadnice je x_2.

Redukovaná hmota musí mít stejnou kinetickou energii jako soustava.

$$\frac{1}{2} m_{red} \cdot \dot{x}_2^2 = \frac{1}{2} m_2 \dot{x}_2^2 + \frac{1}{2} m_3 \dot{y}_3^2 \quad / \cdot \frac{1}{\dot{x}_2^2} \quad ①$$

$$m_{red} = m_2 + m_3 \cdot \left(\frac{\dot{y}_3}{\dot{x}_2}\right)^2 \quad ②$$

z kin $\frac{\dot{y}_3}{\dot{x}_2} = \frac{dy_3}{dx_2} = y'_{23}$ (Převodová funkce)

kinematika: $\operatorname{tg}\beta = \frac{y}{d - x_2} \rightarrow y = (d - x_2) \cdot \operatorname{tg}\beta \quad ③$

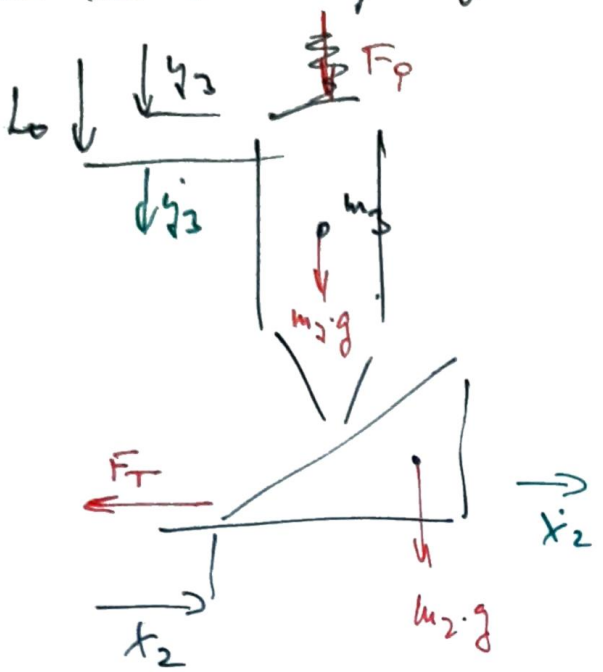
$$H = y_3 + C + (d - x_2) \cdot \operatorname{tg}\beta \quad ④$$

$$H = y_3 + C + d \operatorname{tg}\beta - x_2 \cdot \operatorname{tg}\beta \quad / \frac{d}{dx_2}$$

$$0 = \frac{dy_3}{dx_2} - \operatorname{tg}\beta \rightarrow \frac{dy_3}{dx_2} = \operatorname{tg}\beta \quad ⑤$$

$$m_{red} = m_2 + m_3 \operatorname{tg}^2\beta \quad ⑥$$

Redukovaná síla Q musí mít stejný výkon jako vnější síly působící na soustavu. Připomínáme, že reakce nemají výkon.



$v_{2y}=0$

$$Q \cdot \dot{x}_2 = F_T \cdot \dot{y}_3 + m_3 \cdot g \cdot \dot{y}_3 + m_2 \cdot g \cdot \overset{\downarrow}{0} - F_T \cdot \dot{x}_2 \quad / \cdot \frac{1}{\dot{x}_2} \quad (7)$$

$$Q = F_p \cdot \frac{\dot{y}_3}{\dot{x}_2} + m_3 g \frac{\dot{y}_3}{\dot{x}_2} - F_T \quad (8)$$

(5)→(8) $$Q = F_p \cdot \operatorname{tg}\beta + m_3 g \cdot \operatorname{tg}\beta - F_T \quad (9)$$

$$F_p = k \cdot (L_0 - y_3) \quad (10)$$

(4) → $y_3 = H - C - (d - x_2)\operatorname{tg}\beta$ → (10)

$$F_p = k \cdot (L_0 - H + C + (d - x_2)\operatorname{tg}\beta) \quad (11)$$

$$F_T = b \cdot \dot{x}_2 \quad (12)$$

(11) (12) → (9)

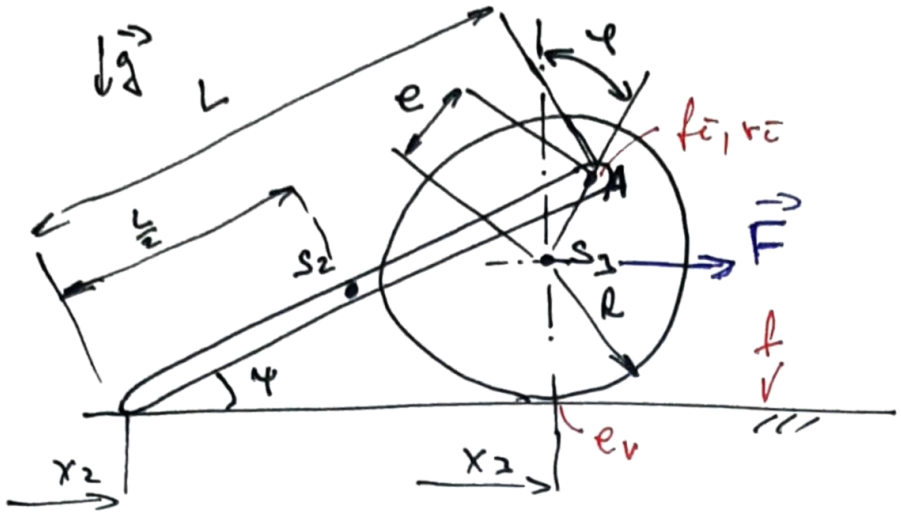
$$Q = k \cdot \operatorname{tg}\beta\,(L_0 - H + C + (d - x_2)\operatorname{tg}\beta) + m_3 g \operatorname{tg}\beta - b\dot{x}_2 \quad (13)$$

z předu:

m_{red} = konst.

$$\frac{1}{2}\frac{dm_{red}}{dq_i}\dot{q}_i^2 + m_{red}\ddot{q}_i = Q \quad \text{kde } q_i = x_2$$

$$\ddot{x}_2 (m_2 + m_3 \operatorname{tg}^2\beta) + b\dot{x}_2 + k\operatorname{tg}^2\beta\, x_2 = k\operatorname{tg}\beta(L_0 - H + c + d\operatorname{tg}\beta) + m_3 g \operatorname{tg}\beta$$



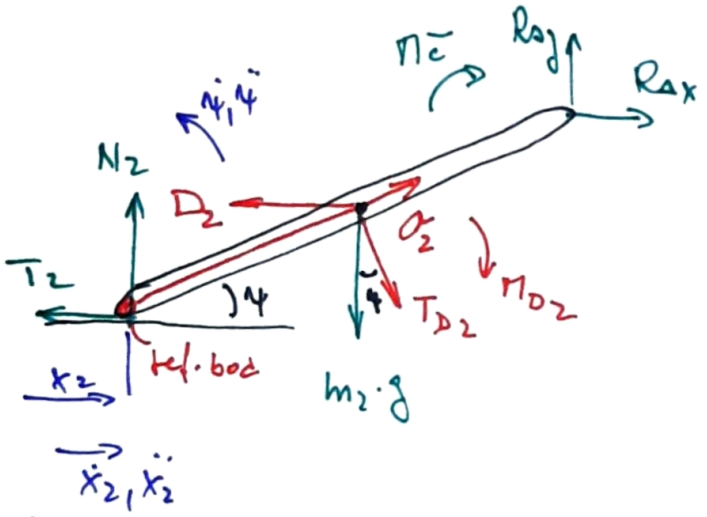
D: L, R, e

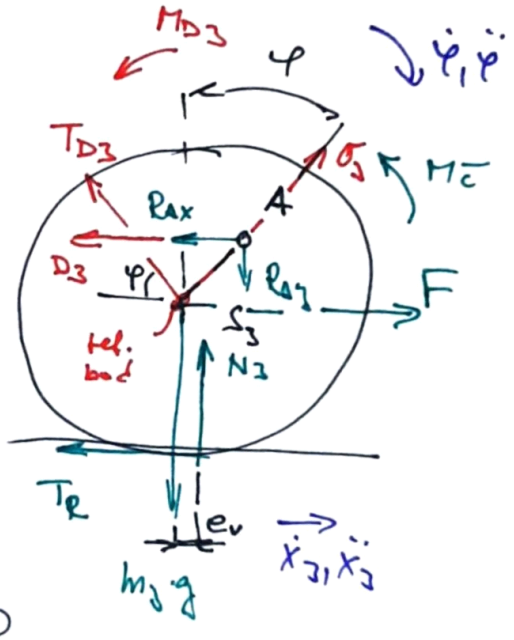
e_v, f, r_c, f_c

F, g

m_2, J_{S2}, m_3, J_{S3}

U: soustava rovnic pro dyn. řešení





těleso 2

$\rightarrow x: \; -T_2 - D_2 + \sigma_2 \cos\varphi + T_{D2} \sin\varphi + R_{ax} = 0$ ①

$\uparrow y: \; N_2 - m_2 g + \sigma_2 \sin\varphi - T_{D2} \cos\varphi + R_{ay} = 0$ ②

$\curvearrowright S_2: \; N_2 \cdot \frac{L}{2} \cdot \cos\varphi - R_{ay} \frac{L}{2} \cos\varphi + T_2 \cdot \frac{L}{2} \sin\varphi + R_{ax} \cdot \frac{L}{2} \sin\varphi + M_{c1} + M_{D2} = 0$ ③

těleso 3

$\rightarrow x: \; -D_3 - R_{ax} - T_R + F - T_{D3} \cos\varphi + \sigma_3 \sin\varphi = 0$ ④

$\uparrow y: \; -m_3 g - R_{ay} + N_3 + T_{D3} \sin\varphi + \sigma_3 \cos\varphi = 0$ ⑤

$\curvearrowright S_3: \; -N_3 \cdot e_v + T_R \cdot R - D_3 \cdot e \cdot \cos\varphi - R_{ax} e \cos\varphi + R_{ay} \cdot e \cdot \sin\varphi - M_c - M_{D3} = 0$ ⑥

Specifikace sil

$T_2 = N_2 \cdot f$ (7)

$T_{D2} = m_2 \cdot \frac{L}{2} \cdot \ddot{\psi}$ (8)

$\sigma_2 = m_2 \cdot \frac{L}{2} \dot{\psi}^2$ (9)

$M_{D2} = \ddot{\psi} \cdot J_{S2}$ (10)

$M_{\bar{c}} = \sqrt{R_{0x}^2 + R_{0y}^2} \cdot r_{\bar{c}} \cdot f_{\bar{c}}$ (11)

$T_{D3} = m_3 \cdot e \cdot \ddot{\varphi}$ (12)

$\sigma_3 = m_3 \cdot e \cdot \dot{\varphi}^2$ (13)

$M_{D3} = J_{S3} \cdot \ddot{\varphi}$ (14)

$D_2 = m_2 \cdot \ddot{x}_2$ (15)
17

$D_2 = m_2 \cdot \ddot{x}_3$ (16)
18

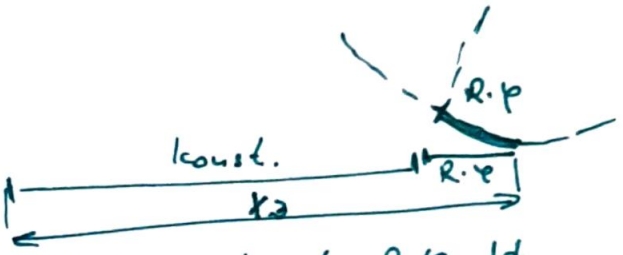
Zapomněl jsem na φ
19

16 rov. 19 neznámých → 3 rov. řešbí!

2 lin.

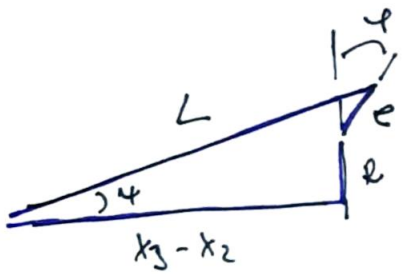
$\dot{x}_3 = R \cdot \dot{\varphi}$ (17)

pozn.



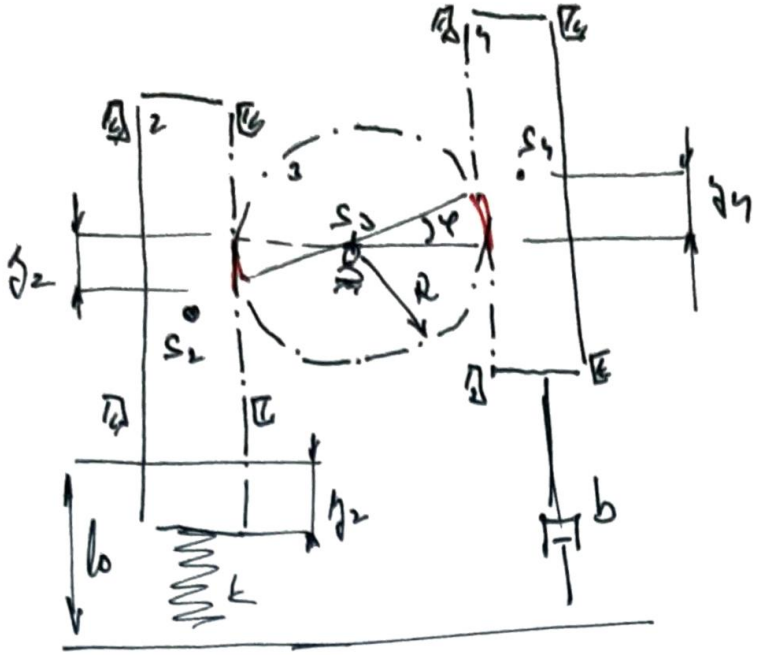
$x_2 = \text{konst.} + R \cdot \varphi \quad | \frac{d}{dt}$

$\dot{x}_3 = R \cdot \dot{\varphi}, \ \ddot{x}_3 = R \ddot{\varphi}$



$L \cdot \cos\psi - e \sin\varphi = x_3 - x_2$ (18)

$L \cdot \sin\psi - e \cos\varphi - R = 0$ (19)



D: m_2, m_3, m_4, J_{S3}, R
k, l_0, b, g
U: $f(\varphi, \dot\varphi, \ddot\varphi) = 0$

bez pasivních odporů → redukční metoda

$q_i = \varphi$

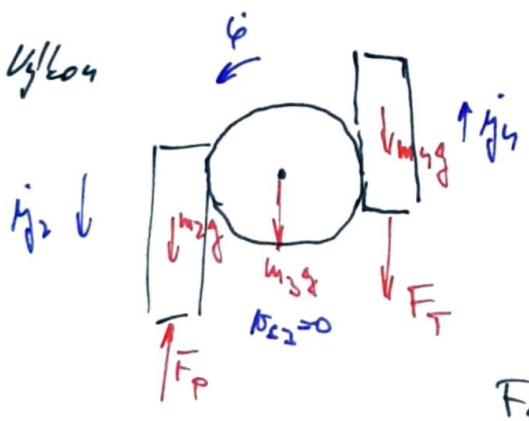
kinetická energie

$$\frac{1}{2} m_{red} \cdot \dot q_i^2 = \frac{1}{2} m_{red} \cdot \dot\varphi^2 = \frac{1}{2} m_2 \dot y_2^2 + \frac{1}{2} J_{S3} \dot\varphi^2 + \frac{1}{2} m_4 \dot y_4^2$$

$$m_{red} = m_2 \cdot \left(\frac{\dot y_2}{\dot\varphi}\right)^2 + J_{S3} + m_4 \left(\frac{\dot y_4}{\dot\varphi}\right)^2$$

$$\dot y_2 = \dot y_4 - R \cdot \dot\varphi$$

$$\boxed{m_{red} = m_2 \cdot R^2 + J_{S3} + m_4 R^2}$$



$$P = Q \cdot \dot q_i = Q \cdot \dot\varphi = (m_2 g - F_P)\dot y_2 - (m_4 g + F_T)\dot y_4$$

$$Q = (m_2 g - F_P)\cdot R - (m_4 g + F_T)\cdot l$$

$$F_P = k \cdot y_2 - k \cdot l_0 \cdot \varphi$$

$$F_T = b \cdot \dot y_4 = b \cdot R \dot\varphi$$

$m_{red} = \text{konst.}$

$$\frac{d m_{red}}{dq_i} \cdot \dot q_i^2 + m_{red} \ddot q_i = Q \qquad (m_2 R^2 + J_{S3} + m_4 R^2)\ddot\varphi = m_2 g R - k R^2 \varphi - m_4 g R - b R^2 \dot\varphi$$

$$\ddot\varphi\left[(m_2 + m_4)R^2 + J_{S3}\right] + \dot\varphi b R^2 + \varphi k R^2 = g R (m_2 + m_4)$$