a) Satz der projezierten Geschwindigkeiten

$\underline{v}_D$: Projektion von V nach D hat keine y-Komponente → macht keinen Sinn

$$\underline{r}_{AB} = \begin{pmatrix} 0 \\ h \\ 0 \end{pmatrix}, \quad \underline{r}_{BD} = \begin{pmatrix} -2h \\ h \\ 0 \end{pmatrix}, \quad \underline{r}_{TD} = \begin{pmatrix} -2h \\ h \\ 8/3\, h \end{pmatrix}$$

$$\underline{v}_D \cdot \underline{r}_{AD} = \underline{v}_A \cdot \underline{r}_{AD} \rightarrow v\begin{pmatrix} -11/5 \\ v_{Dy} \\ -\frac{2}{5} \end{pmatrix} \cdot h\begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix} = v\begin{pmatrix} 1 \\ 0 \\ 2 \end{pmatrix} \cdot h\begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix} \rightarrow v_{Dy} = 0$$

$\underline{v}_T$: Projektion von V nach T hat keine z-Komponente → macht keinen Sinn

$$\underline{r}_{AT} = h\begin{pmatrix} 2 \\ 0 \\ -8/3 \end{pmatrix}, \quad \underline{r}_{BT} = h\begin{pmatrix} 0 \\ 0 \\ -8/3 \end{pmatrix}, \quad \underline{r}_{DT} = h\begin{pmatrix} 2 \\ -1 \\ -8/3 \end{pmatrix}$$

$$\underline{v}_T \cdot \underline{r}_{BT} = \underline{v}_B \cdot \underline{r}_{BT} \rightarrow v\begin{pmatrix} 1 \\ 0 \\ T_z \end{pmatrix} \cdot h\begin{pmatrix} 0 \\ 0 \\ -8/3 \end{pmatrix} = v\begin{pmatrix} 1 \\ \frac{32}{5} \\ 2 \end{pmatrix} \cdot h\begin{pmatrix} 0 \\ 0 \\ -8/3 \end{pmatrix} \rightarrow v_{Tz} = 2v$$

b) $$\underline{r}_{TV} = h\begin{pmatrix} -2 \\ 1 \\ 0 \end{pmatrix}, \quad \underline{r}_{DV} = h\begin{pmatrix} 0 \\ 0 \\ -8/3 \end{pmatrix}$$

$$\underline{v}_2 = \underline{v}_1 + \underline{w} \times \underline{r}_{12} \rightarrow \underline{v}_D = \underline{v}_A + \underline{w} \times \underline{r}_{AD} \rightarrow -\frac{v}{5}\begin{pmatrix} 11 \\ 0 \\ 2 \end{pmatrix} = v\begin{pmatrix} 1 \\ 0 \\ 2 \end{pmatrix} + \begin{pmatrix} w_x \\ w_y \\ w_z \end{pmatrix} \times \begin{pmatrix} 0 \\ h \\ 0 \end{pmatrix}$$

$$\Rightarrow \begin{pmatrix} +w_z h \\ 0 \\ -w_x h \end{pmatrix} = v\begin{pmatrix} 1 + \frac{11}{5} \\ 0 \\ 2 + \frac{2}{5} \end{pmatrix} \rightarrow w_z = \frac{v}{h}\frac{16}{5}, \quad \rightarrow w_x = -\frac{v}{h}\frac{12}{5}$$

$$\underline{v}_D = \underline{v}_V + \underline{w} \times \underline{r}_{VD} \rightarrow -\frac{v}{5}\begin{pmatrix} 11 \\ 0 \\ 2 \end{pmatrix} = -\frac{v}{5}\begin{pmatrix} 11 \\ 32 \\ 5 \end{pmatrix} + \begin{pmatrix} w_x \\ w_y \\ w_z \end{pmatrix} \times \begin{pmatrix} 0 \\ 0 \\ 8/3\, h \end{pmatrix}$$

→ nur x-Komponente der Geschwindigkeit betrachten, da w_x & w_z schon bestimmt.

$$-\frac{11}{5}v = -\frac{11}{5}v + w_y \cdot \frac{8}{3}h \rightarrow w_y = 0$$

$$\Rightarrow \underline{w} = \frac{v}{h}\frac{4}{5}\begin{pmatrix} -3 \\ 0 \\ 4 \end{pmatrix}$$

c) $\underline{w} \neq 0$

$$\underline{v}_A \cdot \underline{w} = v\begin{pmatrix} 1 \\ 0 \\ 2 \end{pmatrix} \cdot \frac{v}{h}\frac{4}{5}\begin{pmatrix} -3 \\ 0 \\ 4 \end{pmatrix} = 4\frac{v^2}{h} \neq 0$$

→ Schraubung

a) $\sum F_{i,x} \overset{!}{=} 0$: $B_x - A_x = 0 \rightarrow A_x = B_x$

$\sum F_{i,y} \overset{!}{=} 0$: $A_y - G - P = 0 \rightarrow A_y = G + P$

$\sum M_{i,A} \overset{!}{=} 0$: $2aG - 8aB_x - 10aP = 0 \rightarrow B_x = \frac{1}{4}(G - 5P)$

b) $B_x \geq 0 \rightarrow G \geq 5P$

c) 4 SK

d) $\underline{v}_0^1 = \underline{v}_0^3 \rightarrow \tilde{\omega} a \begin{pmatrix} -3 \\ 1 \end{pmatrix} = \omega_3 a \begin{pmatrix} -1 \\ 1/3 \end{pmatrix}$ $\quad \omega_3 = 3\tilde{\omega}$

$\underline{v}_E^1 = \underline{v}_E^4 \rightarrow \tilde{\omega} a \begin{pmatrix} -3 \\ 0 \end{pmatrix} = \omega_4 a \begin{pmatrix} -1 \\ 0 \end{pmatrix}$ $\quad \omega_4 = 3\tilde{\omega}$

$\underline{v}_S^2 = \underline{v}_S^4 \rightarrow \omega_4 a \begin{pmatrix} 1 \\ 0 \end{pmatrix} = \omega_2 a \begin{pmatrix} 3 \\ 0 \end{pmatrix}$ $\quad \omega_2 = \frac{1}{3}\omega_4 = \tilde{\omega}$

Gleiche Aussagen unter Verwendung des "Parallelogrammsatzes". Es muss trotzdem eine Stabwinkelgeschwindigkeit (ω_{3} oder ω_4) berechnet werden

e) $\underline{v}_C = 7a\tilde{\omega}\begin{pmatrix} -1 \\ 0 \end{pmatrix}$, $\underline{v}_B = 9\tilde{\omega}\begin{pmatrix} 0 \\ -1 \end{pmatrix}$, $\underline{v}_F = a\tilde{\omega}\begin{pmatrix} -1 \\ -2 \end{pmatrix}$, $\underline{v}_H = a\tilde{\omega}\begin{pmatrix} -8 \\ +10 \end{pmatrix}$

f) $P_C = \frac{S}{\sqrt{2}}\begin{pmatrix} -1 \\ 1 \end{pmatrix} \cdot 7a\tilde{\omega}\begin{pmatrix} -1 \\ 0 \end{pmatrix} = Sa\tilde{\omega}\frac{7}{\sqrt{2}}$

$P_B = \frac{S}{\sqrt{2}}\begin{pmatrix} 1 \\ -1 \end{pmatrix} \cdot 9\tilde{\omega}\begin{pmatrix} 0 \\ -1 \end{pmatrix} = Sa\tilde{\omega}\frac{9}{\sqrt{2}}$

$P_F = G\begin{pmatrix} 0 \\ -1 \end{pmatrix} \cdot a\tilde{\omega}\begin{pmatrix} -1 \\ -2 \end{pmatrix} = 2a\tilde{\omega}G$

$P_H = P\begin{pmatrix} 0 \\ -1 \end{pmatrix} \cdot a\tilde{\omega}\begin{pmatrix} -8 \\ +10 \end{pmatrix} = -10a\tilde{\omega}P$

$\delta P = \sum P_i \overset{!}{=} 0 \rightarrow \frac{16}{\sqrt{2}}\cancel{a\tilde{\omega}}S + 2\cancel{a\tilde{\omega}}G - 10\cancel{a\tilde{\omega}}P = 0$

$\frac{16}{\sqrt{2}}S = 2(5P - G)$

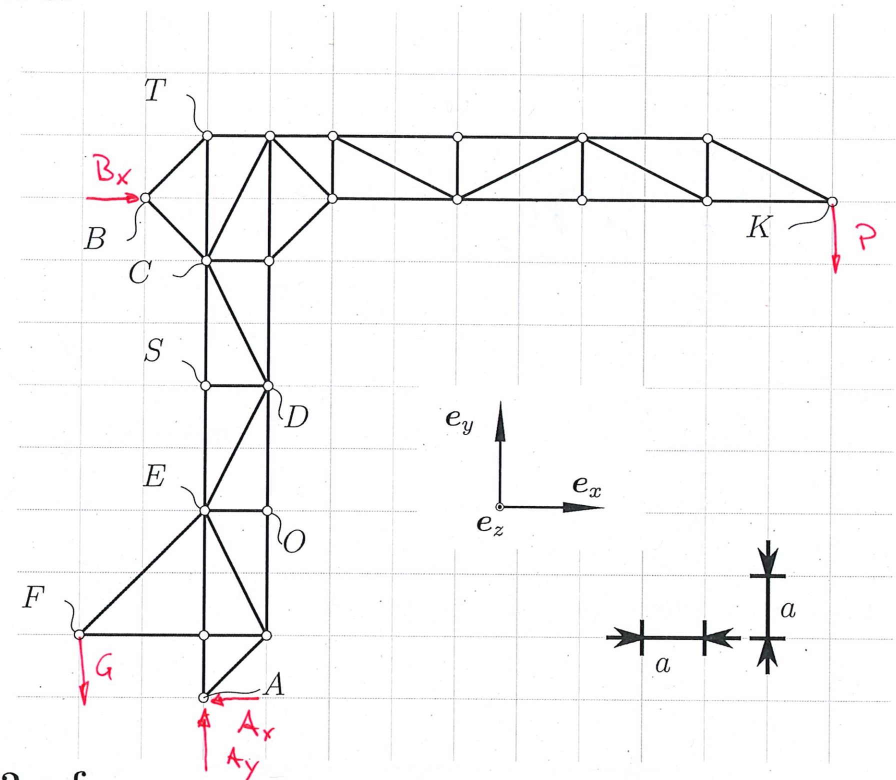
$S = \frac{\sqrt{2}}{8}(5P - G)$

S Zugstab, wenn $5P > G$ | unter b) $G \geq 5P$, damit Ruhelage

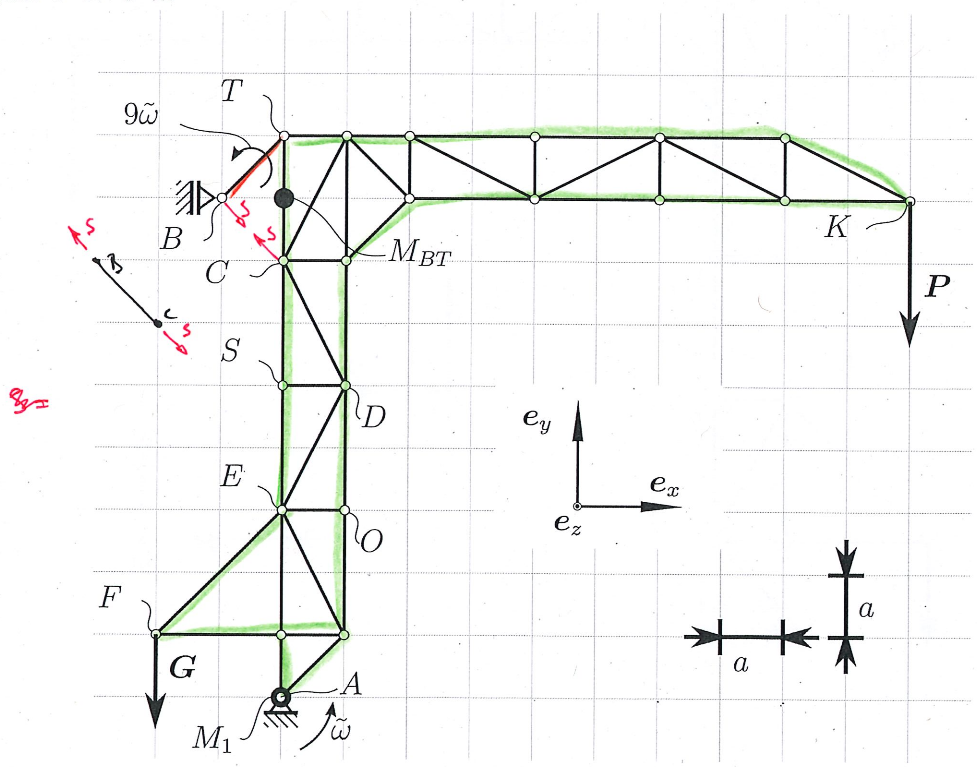
Druckstab sonst | $\rightarrow$ BC ist Druckstab

Name:	Vorname:	ETH-Nummer:	Studiengang: D -

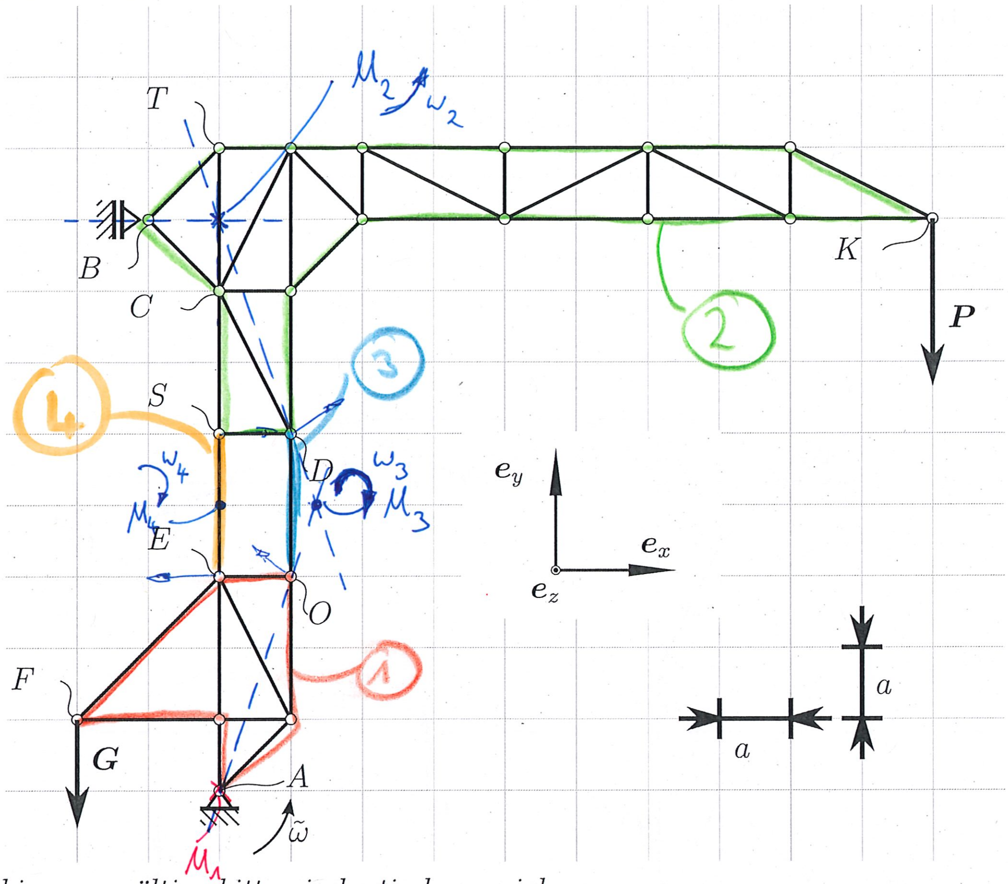
Aufgabe 2 a.



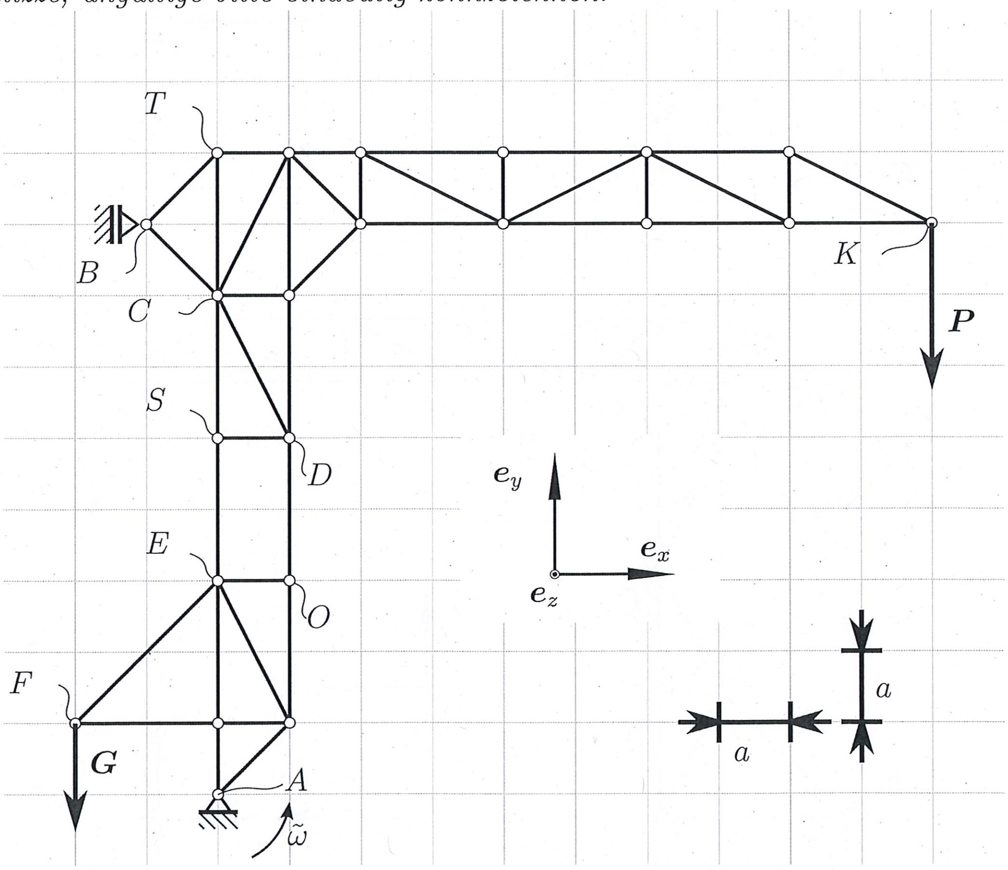
Aufgabe 2 e-f.



Aufgabe 2 c-d.



Reserveskizze; ungültige bitte eindeutig kennzeichnen.



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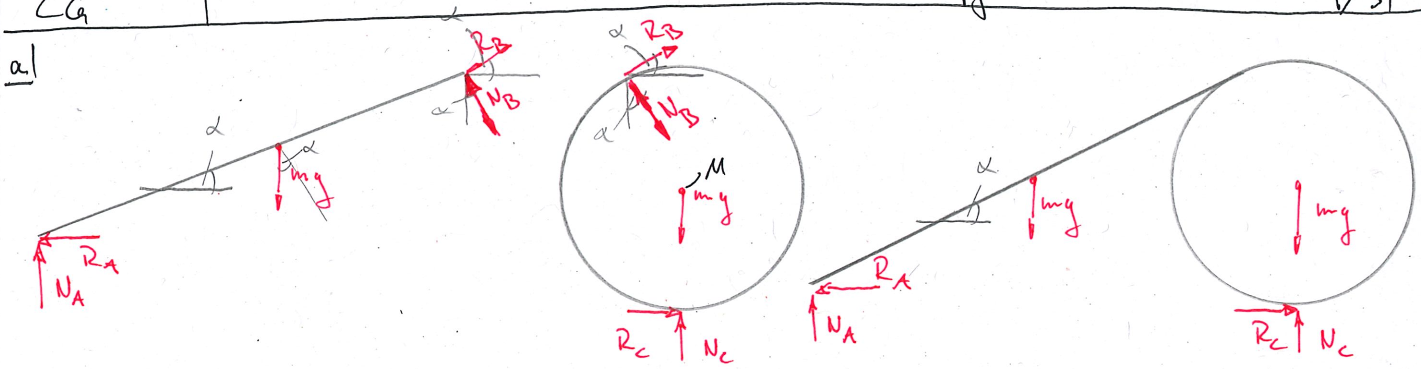
CG

a)



b)

$$\sum F_{i,x} \overset{!}{=} 0 : \quad -N_B \sin\alpha - R_B \cos\alpha - R_A = 0 \quad (1) \qquad R_C + R_B \cos\alpha + N_B \sin\alpha = 0 \quad (4) \qquad R_C - R_A = 0 \quad (7)$$

$$\sum F_{i,y} \overset{!}{=} 0 : \quad N_A + N_B \cos\alpha - R_B \sin\alpha - mg = 0 \quad (2) \qquad N_C + R_B \sin\alpha - N_B \cos\alpha - mg = 0 \quad (5) \qquad N_A + N_C - mg - mg = 0 \quad (8)$$

$$\sum M_{i,j} \overset{!}{=} 0 ; \quad j=A: \; -\frac{L}{2} mg \cos\alpha + L N_B = 0 \quad (3) \qquad j=M: \; R \cdot R_C - R \cdot R_B = 0 \quad (6) \qquad j=A: \; -\frac{L}{2} mg \cos\alpha - Lmg + L N_C = 0 \quad (9)$$

c)

$$(6): \quad R_B = R_C \qquad (7): \quad R_A = R_C = R_B$$

$$(9): \quad N_C = mg \left(1 + \frac{\cos\alpha}{2}\right) = mg \left(1 + \frac{\sqrt{3}}{4}\right)$$

$$(8): \quad N_A = 2mg - N_C = mg \left(1 - \frac{\sqrt{3}}{4}\right)$$

$$(3): \quad N_B = + \frac{mg}{2} \cos\alpha = mg \frac{\sqrt{3}}{4}$$

$$(2): \quad R_B = \frac{-1}{\sin\alpha} \left(mg - N_A - N_B \cos\alpha\right) = \frac{-1}{1/2} \left(mg - mg\left(1 - \frac{\sqrt{3}}{4}\right) - mg \frac{\sqrt{3}}{4} \cdot \frac{\sqrt{3}}{2}\right) =$$

$$= -2 \left(\frac{\sqrt{3}}{4} mg - \frac{3}{8} mg\right) = -mg \left(\frac{\sqrt{3}}{2} - \frac{\sqrt{3}\sqrt{3}}{4}\right) = \frac{-mg}{4} \left(2\sqrt{3} - 3\right)$$

d)

$$\mu_0 \cdot N_i \geq |R_i|$$

$$\mu_0 \geq \frac{R_i}{N_i}$$ alle R_i sind gleich gross

→ μ_0 muss Bedingung mit kleinsten N_i erfüllen, dann sind andere beiden auch automatisch erfüllt

$$|N_C| > |N_A| > |N_B|$$

$$\rightarrow \mu_0 \geq \left|\frac{R_B}{N_B}\right| \rightarrow \left|\frac{(2\sqrt{3} - 3)\cancel{mg}}{\sqrt{3}\,\cancel{mg}}\right| = 2 - \sqrt{3}$$

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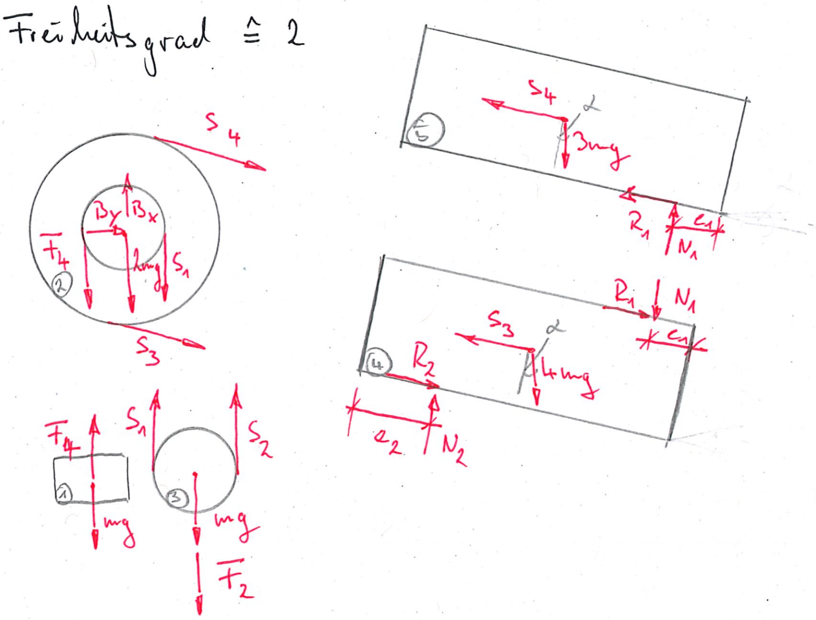
a) Freiheitsgrad $\hat{=}$ 2

b)



c) ①: $m\ddot{x}_4 = mg - F_4$

②: $I_1 \ddot{\varphi}_1 = 2r(S_3 - S_4) + r(F_4 - S_1)$

③: $m\ddot{x}_2 = mg + F_2 - S_1 - S_2$ (1)

$I_2 \ddot{\varphi}_2 = r(S_2 - S_1)$ (2)

④: $4m\ddot{x}_3 = R_1 + R_2 + 4mg\sin\alpha - S_3$

⑤: $3m\ddot{x}_1 = 3mg\sin\alpha - R_1 - S_4$

d) ② & ⑤

$\dot{x}_1 = -\dot{\varphi}_1 2r \rightarrow \dot{\varphi}_1 = -\frac{\dot{x}_1}{2r}$

② & ④

$\dot{x}_3 = \dot{\varphi}_1 2r \rightarrow \dot{x}_3 = -\frac{\dot{x}_1}{2r}\cdot 2r = -\dot{x}_1$

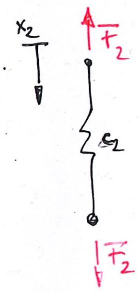
③ &

$\dot{x}_2 = \dot{\varphi}_2 r \rightarrow \dot{x}_2 = \frac{\dot{x}_1}{4r}\cdot r = \frac{\dot{x}_1}{4}$

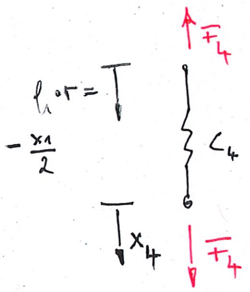
③ & ②

$-\dot{\varphi}_1 r = 2r\dot{\varphi}_2 \rightarrow \dot{\varphi}_2 = -\frac{1}{2}\dot{\varphi}_1 = \frac{\dot{x}_1}{4r}$

d)



$F_2 = -c_2 \cdot x_2 = -c_2 \frac{x_1}{4}$



$F_4 = c_4(x_4 - \varphi_1 \cdot r) = c_4\left[x_4 - \left(-\frac{x_1}{2}\right)\right] = c_4\left(x_4 + \frac{1}{2}x_1\right)$

f) $r\cdot(1) + (2)$:

$I_2\ddot{\varphi}_2 + rm\ddot{x}_2 = rmg + rF_2 - 2rS_1$

$S_1 = \frac{1}{2}\left(-\frac{I_2}{r}\ddot{\varphi}_2 - m\ddot{x}_2 + mg - c_2x_2\right) = \frac{1}{2}\left[(g - \ddot{x}_2)m - c_2x_2 - \frac{I_2}{r}\ddot{\varphi}_2\right]$

$r(1) - (2)$:

$rm\ddot{x}_2 - I_2\ddot{\varphi}_2 = rmg + rF_2 - 2rS_2$

$S_2 = \frac{1}{2}\left[\frac{I_2}{r}\ddot{\varphi}_2 + (g - \ddot{x}_2)m - c_2x_2\right]$