1.

a.)

$$\underline{e}_K = \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} \qquad 1_1$$

$$\underline{e}_G = \begin{bmatrix} 1 \cdot \cos 45° \\ 0 \\ -1 \cdot \sin 45° \end{bmatrix} = \begin{bmatrix} \sqrt{2}/2 \\ 0 \\ -\sqrt{2}/2 \end{bmatrix} \qquad 1_2$$

$$\underline{e}_S = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \qquad 1_3$$

can also be in negative direction

b.)

$$\underline{\omega}_K = \begin{bmatrix} 0 \\ -\omega \\ 0 \end{bmatrix} \qquad r_H = b \cdot \tan \frac{60°}{2} \qquad 1_4$$

$$1_5^{KR}$$

$$\underline{v}_H = \begin{bmatrix} +\omega \cdot r_H \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} \omega b \tan 30° \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} \frac{\sqrt{3}}{3} \omega b \\ 0 \\ 0 \end{bmatrix}$$

c.)

$$\underline{v}_L = \begin{bmatrix} 0 \\ \omega_S^z \cdot x \\ 0 \end{bmatrix} \; 1_6 \; = \begin{bmatrix} 0 \\ -\frac{v_H^x}{r} \cdot x \\ 0 \end{bmatrix} = \begin{bmatrix} 0 \\ -\frac{\sqrt{3}}{3} \frac{\omega b}{r} x \\ 0 \end{bmatrix} \qquad 1_7$$

$$\omega_S^z = -\frac{v_H^x}{r}$$

$$\underline{\omega}_S = \begin{bmatrix} 0 \\ 0 \\ -\frac{v_H^x}{r} \end{bmatrix}$$

$$\underline{v}_D = \begin{bmatrix} 0 \\ -\frac{\sqrt{3}}{3}\frac{\omega b}{r}(a-r) \\ 0 \end{bmatrix} \qquad 1_{8}$$

$$\underline{v}_E = \begin{bmatrix} 0 \\ \frac{\sqrt{3}}{3}\omega b \\ 0 \end{bmatrix} \qquad 1_{9}$$

$$\underline{v}_C = \begin{bmatrix} 0 \\ \frac{\sqrt{3}}{3}\frac{\omega b}{r}(a-r) \\ 0 \end{bmatrix} \qquad 1_{10}$$

d.)

$$\underline{\omega}_K = \begin{bmatrix} 0 \\ -\omega \\ 0 \end{bmatrix}$$

$$\underline{\omega}_S = \begin{bmatrix} 0 \\ 0 \\ -\frac{\sqrt{3}}{3}\frac{\omega b}{r} \end{bmatrix} \qquad 1_{11}$$

+ Comput. r_E as well

$$r_d = \frac{\sqrt{(r-a)^2 \cdot 2}}{2}$$

$$r_d = \frac{\sqrt{2}}{2}(r-a) \qquad 1_{12}$$

$$\underline{\omega}_G \Rightarrow \quad |\omega_G| = |v_D^y| / r_D = \frac{\sqrt{6}}{3}\frac{\omega b}{r}$$

$$\underline{\omega}_G = \underline{e}_G\, |\omega_G| = \begin{bmatrix} \sqrt{2}/2 \\ 0 \\ -\sqrt{2}/2 \end{bmatrix} \frac{\sqrt{6}}{3}\frac{\omega b}{r} \qquad 1_{13}$$

e.)

$$K_G^D = \{\underline{v}_D, \underline{\omega}_G\} \; ; \; K_S^D = \{\underline{v}_D, \underline{\omega}_S\}$$

1_{14} $\quad$ 1_{15}

g.)

$$P_G = \underline{M}_G \cdot \underline{\omega}_G = -M_G \frac{\sqrt{6}}{3} \frac{\omega b}{r} \qquad \textcircled{1}_{16}$$

$$P_K = \underline{M}_K \cdot \underline{\omega}_K = M_K \omega \qquad \textcircled{1}_{17}$$

h.)

$$P_G + P_K = 0 \qquad \textcircled{1}_{18}$$

$$\hookrightarrow \quad M_G \frac{\sqrt{6}}{3} \frac{\omega b}{r} = M_K \omega$$

$$\hookrightarrow \quad \frac{M_G}{M_K} = \frac{3r}{\sqrt{6}\, b} \qquad \textcircled{1}_{19}^{(KR)}$$

h.) u_m

$$\begin{bmatrix} \sqrt{2}/2 \\ 0 \\ -\sqrt{2}/2 \end{bmatrix} \frac{\sqrt{6}}{3} \frac{2\omega b}{r} \; . \qquad \textcircled{1}_{21}^{(KR)}$$

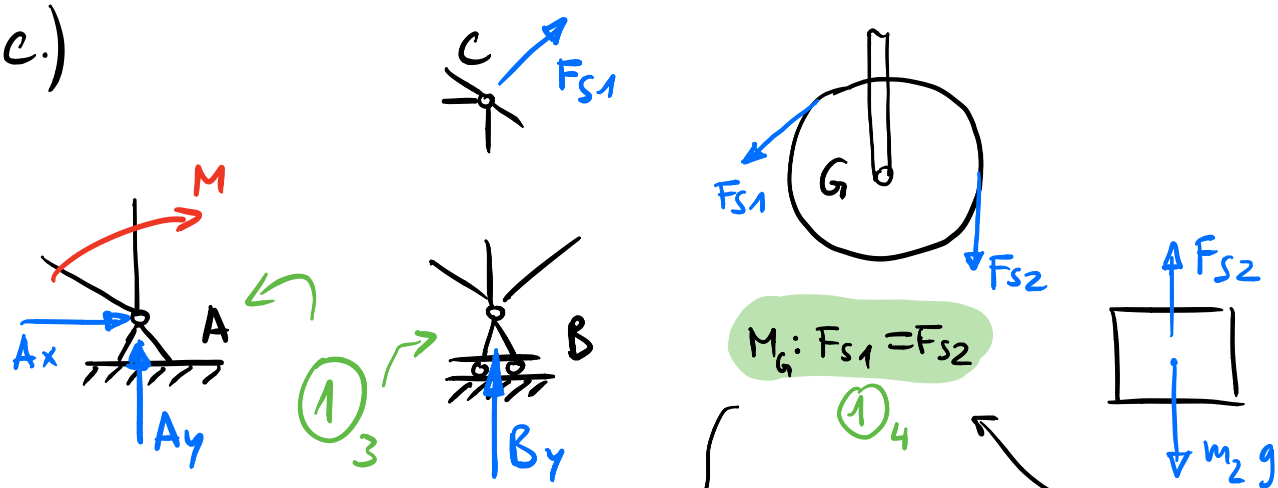
$\textcircled{1}_{20}$ ← for understanding the question correctly (e.g. $\omega_{new} = \omega_{old} + 2\omega$)

2.

a.) Nein. $U = 3 \;/\; G = 3$ $(1)_1$

b.) Nein. No motion possible. $(1)_2$

c.)



$(1)_3$

M_G: $F_{S1} = F_{S2}$ $(1)_4$

$(1)_5$

$$X:\quad A_x + \frac{\sqrt{2}}{2} F_{S1} = 0$$

$$Y:\quad A_y + B_y - m_1 g - F + \frac{\sqrt{2}}{2} F_{S1} = 0$$

$$M_A:\quad aB_y - M + aF = 0$$

$$B_y = \frac{M}{a} - F \qquad (1)_8$$

$$A_y = 2F - \frac{M}{a} + m_1 g - \frac{\sqrt{2}}{2} m_2 g \qquad (1)_7$$

$$A_x = -\frac{\sqrt{2}}{2} m_2 g \qquad (1)_6$$

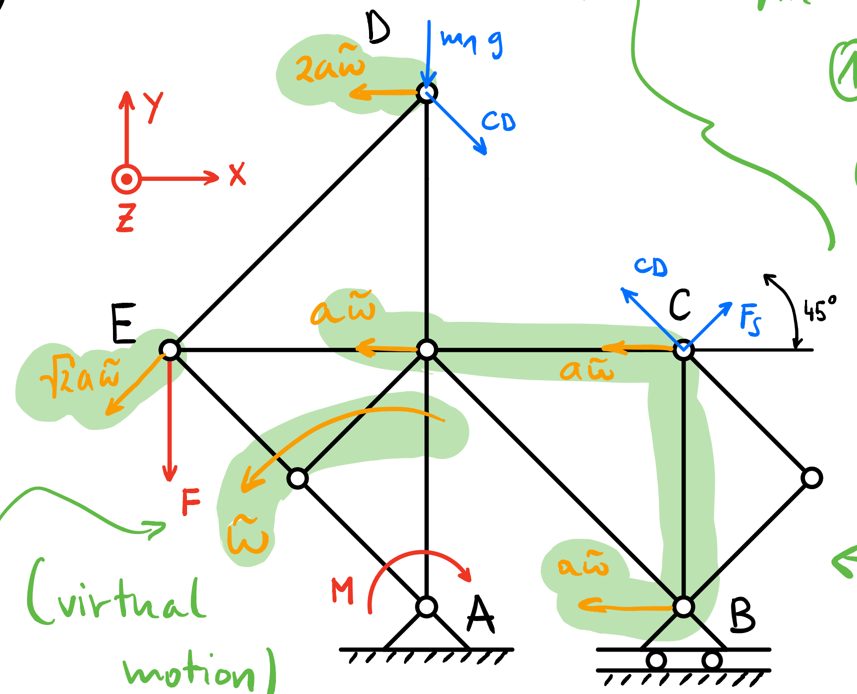
X: $0 = 0$

Y: $F_{S2} = m_2 g$

M: $0 = 0$

d.) $F_S = m_2 g$ $(1)_9$

e.)



All velocities correct
1$_{12}$, 1$_{13}$
(−1 for each mistake)

1$_{11}$ (virtual motion)

1$_{10}$ (virtual motion)

$$P_{TOT} = 0 = P_A + P_E + P_D + P_C + P_B$$ 1$_{14}$

$$P_A = -M\tilde{\omega}$$ 1$_{15}$

$$P_E = \sqrt{2}\,a\tilde{\omega}\cdot\frac{\sqrt{2}}{2}F = a\tilde{\omega}F$$ 1$_{16}$

$$P_D = -2a\tilde{\omega}\,\frac{\sqrt{2}}{2}CD = -\sqrt{2}\,a\tilde{\omega}\,CD$$ 1$_{17}$

$$P_C = -a\tilde{\omega}\frac{\sqrt{2}}{2}(F_s - CD)$$ 1$_{18}$

$$P_B = 0$$ 1$_{19}$

$$0 = -M\cancel{\tilde{\omega}} + a\cancel{\tilde{\omega}}F - \sqrt{2}\,a\cancel{\tilde{\omega}}\,CD - a\cancel{\tilde{\omega}}\frac{\sqrt{2}}{2}F_s + a\cancel{\tilde{\omega}}\frac{\sqrt{2}}{2}CD$$

$$CD = \sqrt{2}\left(F - \frac{M}{a}\right) - F_s$$

$$CD = \sqrt{2}\left(F - \frac{M}{a}\right) - m_2 g$$ 1$_{20}$

f.) $CD = 0 \rightarrow M = aF - \frac{\sqrt{2}}{2}a m_2 g$ 1$_{21}$

3.

a.) 2 → Quader und Rolle B   1 $_1$

motion along x

inc. Seil ...

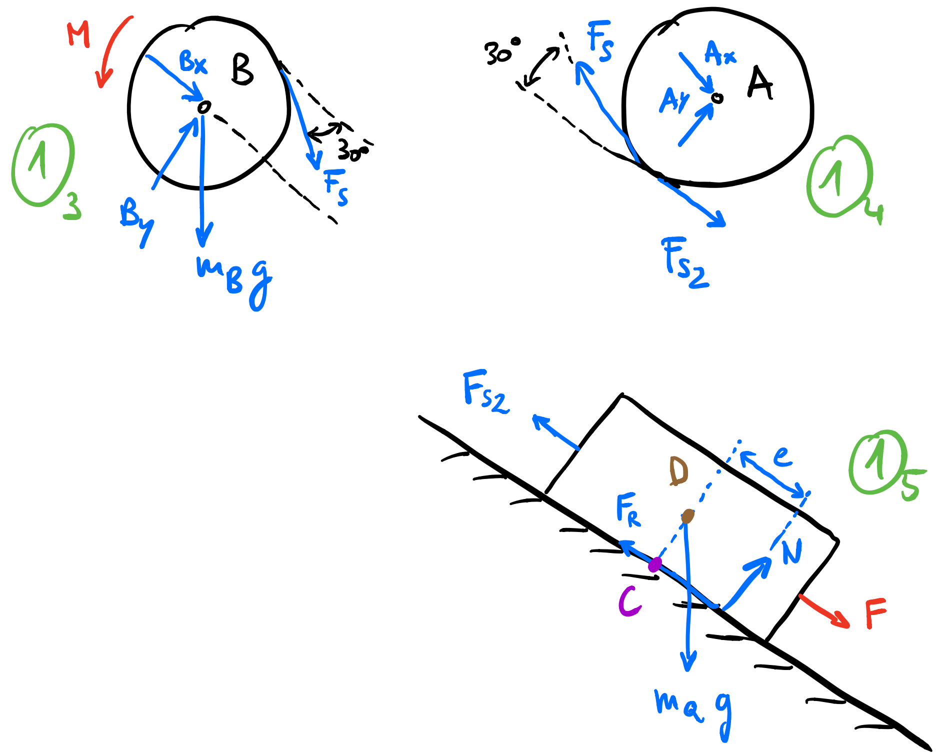
b.)

$$v_S = R_B \dot{\phi}_2 = -R_A \dot{\phi}_1$$

$$\hookrightarrow \quad \dot{\phi}_2 = -\frac{R_A}{R_B}\dot{\phi}_1 \longrightarrow \phi_2 = -\frac{R_A}{R_B}\phi_1$$ 1 $_2$

also counts

c.)



d.) B:

1 $_6^{KR}$

X: $B_x + F_S \cdot \cos 30° + m_B g \frac{1}{2} = 0 \rightarrow B_x = -\frac{\sqrt{3}}{2}\frac{M}{R_B} - \frac{1}{2} m_B g$ 1 $_7^{KR}$

Y: $B_y - F_S \cdot \sin 30° - m_B g \frac{\sqrt{3}}{2} = 0 \rightarrow B_y = \frac{M}{2 \cdot R_B} + \frac{\sqrt{3}}{2} m_B g$

M_B: $M - F_S \cdot R_B = 0 \rightarrow F_S = \frac{M}{R_B}$ 1 $_9^{KR}$ 1 $_8^{KR}$

no point if there is a mistake in one of the eqs.

A:

$(1)^{KR}_{10}$

$$\begin{cases} x: & A_x - F_S \cos 30^\circ + F_{S2} = 0 \\ y: & A_y + F_S \cdot \sin 30^\circ = 0 \\ M_A: & R_A F_{S2} - R_A F_S = 0 \end{cases}$$

$$A_x = \frac{M}{R_B}\left(\frac{\sqrt{3}}{2} - 1\right) \quad (1)^{KR}_{11}$$

$$A_y = -\frac{1}{2}\frac{M}{R_B} \quad (1)^{KR}_{12}$$

$$F_{S2} = F_S \quad (1)^{KR}_{13}$$

Q:

$(1)^{KR}_{14}$

$$\begin{cases} x: & F - F_{S2} - F_R + m_Q\, g \sin 30^\circ = 0 \\ y: & N - m_Q\, g \cos 30^\circ = 0 \\ M_C: & F_{S2} \cdot \frac{a}{2} - F\frac{a}{2} - m_Q g \sin 30^\circ \frac{a}{2} + e\, m_Q\, g \cos 30^\circ = 0 \end{cases}$$

$$\left(M_D: \quad e \cdot N - \frac{a}{2} \cdot F_R = 0\right)$$

$$N = \frac{\sqrt{3}}{2} m_Q\, g \quad (1)^{KR}_{15}$$

$$F_R = F - \frac{M}{R_B} + \frac{1}{2} m_Q\, g \quad (1)^{KR}_{16}$$

$$|F_R| \leq \mu_0 N$$

$$e\left(\frac{\sqrt{3}}{2} m_Q\, g\right) = \frac{a}{2}F - \frac{a}{2}\frac{M}{R_B} + \frac{a}{4} m_Q\, g$$

$$e = \frac{a}{\sqrt{3}\, m_Q\, g}\left[F - \frac{M}{R_B} + \frac{1}{2} m_Q\, g\right] \quad (1)^{KR}_{17}$$

e.)

$(1)_{18}$

$$\begin{cases} |e| > \frac{b}{2} \rightarrow \text{Kippen} \rightarrow \frac{2|e|}{b} > 1 \\ |F_R| < \mu_0 |N| \rightarrow \text{Haftbedingung} \rightarrow \frac{|F_R|}{\mu_0 N} < 1 \end{cases}$$

$$|e| = \frac{a}{2\sqrt{3}} \longrightarrow \frac{2|e|}{b} = \frac{a}{\sqrt{3}\,b} < 1$$ 1_{19}

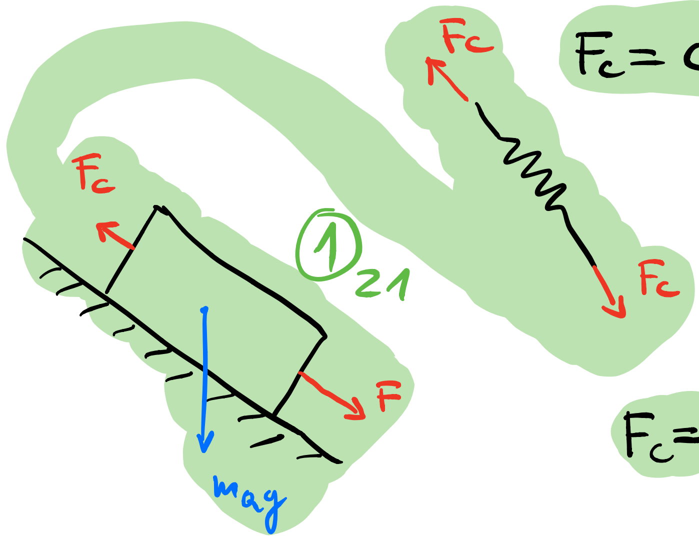
↳ kein kippen

$$|F_R| = \frac{1}{2} m_Q g \,, \quad N = \frac{\sqrt{3}}{2} m_Q g$$

$$\frac{|F_R|}{\mu_0 N} = \frac{1}{\mu_0 \sqrt{3}} < 1 \longrightarrow \text{kein gleiten}$$ 1_{20}

Haftbedingung

f.)



$$F_c = c(x_1 - \phi_1 R_A)$$

$$F_c = c(x_1 + \phi_2 R_B)$$ 1_{22}

$$\ddot{x}_1 m_Q = -F_c + m_Q g \frac{1}{2} + F$$ 1_{23}

$$\ddot{x}_1 m_Q + c x_1 = -c\phi_2 R_B + \frac{1}{2} m_Q g + F$$ 1_{24}

$$\ddot{\phi}_2 I_B = M - F_c \cdot R_B$$ 1_{25}

$$\ddot{\phi}_2 I_B = M - c R_B x_1 - c R_B^2 \phi_2$$ 1_{26}

g.)

$$\left.\begin{aligned}\ddot{x}_1 &= 0 \\ \ddot{\phi}_2 &= 0\end{aligned}\right\} \rightarrow \left.\begin{aligned}F_c &= F + \tfrac{1}{2} m_Q g \\ M &= R_B \cdot F_c\end{aligned}\right\}$$

1 [27]

$$M = R_B \left(F + \tfrac{1}{2} m_Q g \right)$$

1 [28]