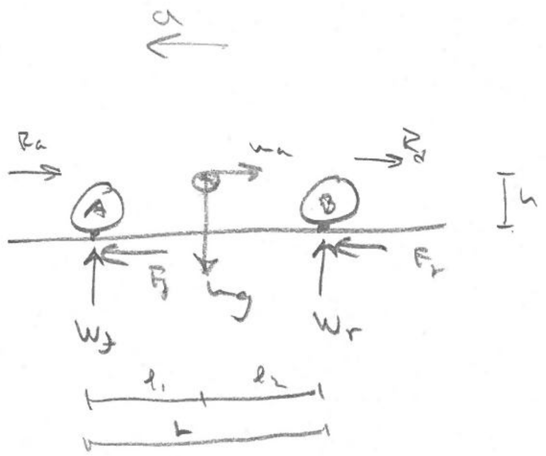
2011-10-22

1)



a) Sökt: W_f, W_r

$\leftarrow$: $\underbrace{F_f + F_r}_{=R} = ma + R_a + R_d$

$\overset{\curvearrowleft}{A}$: $\underbrace{(ma + R_a + R_d)}_{=F} \cdot h + mg\, l_1 - W_r \cdot L = 0 \Leftrightarrow W_r = mg\frac{l_1}{L} + F\frac{h}{L}$ (*)

$\overset{\curvearrowleft}{B}$: $(ma + R_a + R_d)\cdot h - mg\, l_2 + W_f \cdot L = 0 \Leftrightarrow W_f = mg\frac{l_2}{L} - F\frac{h}{L}$

b) Sökt a_{max}

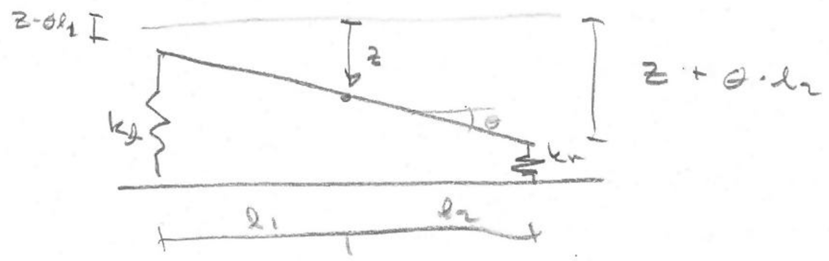
$F_{max} = F_f + F_r = 0 + \mu W_r$

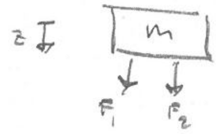
$\overset{(*)}{\Rightarrow} W_r = mg\frac{l_1}{L} + \mu W_r \frac{h}{L} \Leftrightarrow W_r = \left(1 - \frac{\mu h}{L}\right)^{-1} mg\frac{l_1}{L} = 9078\ N$

$F_{max} = ma + R_a + R_d$

$a = \frac{1}{m}\left(F_{max} - R_a - R_d\right) = \frac{1}{m}\left(\mu W_r - R_a - R_d\right) = \underline{4.9\ m/s^2}$

2)





$F_1 = -k_f(z - \theta l_1)$

$F_2 = -k_r(z + \theta l_2)$

a)

$$(\downarrow): \quad m\ddot{z} = F_1 + F_2 = -k_f(z - \theta l_1) - k_r(z + \theta l_2)$$

$$(\curvearrowright): \quad I_y \cdot \ddot{\theta} = -F_1 \cdot l_1 + F_2 \cdot l_2 =$$

$$= l_1 k_f(z - \theta l_1) - l_2 k_r(z + \theta l_2)$$

b) Vi vill ha $\dot{z} = f(z)$

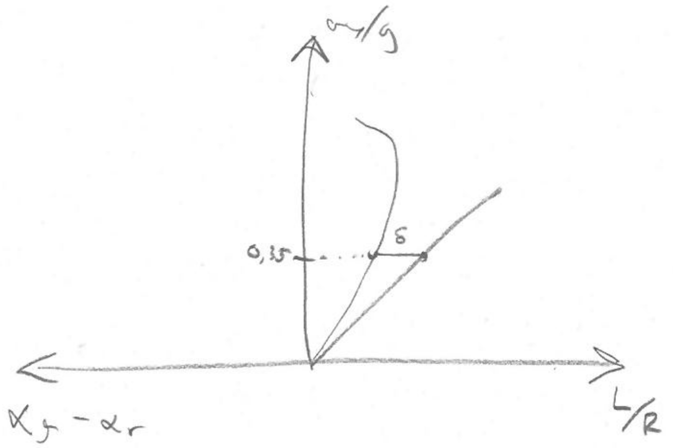
$\dot{\theta} = f(\theta)$

$$\dot{z} = \frac{1}{m}\left[(-k_f - k_r)z + \overbrace{(k_f l_1 - k_r l_2)}^{A}\theta\right]$$

$$\dot{\theta} = \frac{1}{I_y}\left[\underbrace{(k_f l_1 - k_r l_2)}_{B}z + (-k_f l_1^2 - k_r l_2^2)\theta\right]$$

om $k_f l_1 = k_r l_2$ kan vi stryka A, B

3)



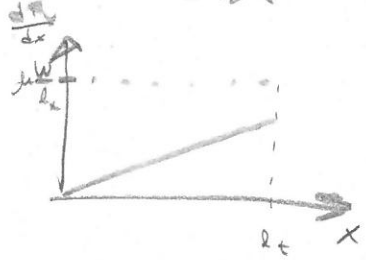
a)

$$a_y = \frac{V^2}{R} \Rightarrow \frac{L}{R} = \frac{gL}{V^2} \cdot \frac{a_y}{g}$$

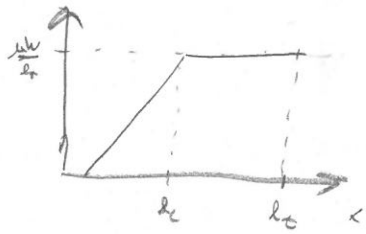
b) $R = 80\ m \Rightarrow \frac{a_y}{g} = \frac{V^2}{gR} = 0{,}35$

4)

Adhesion



Gliding



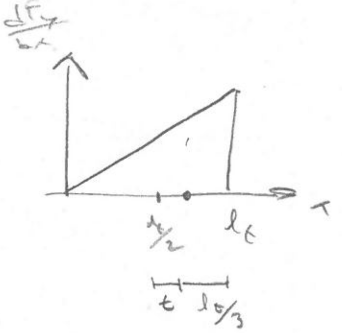
$$\frac{dF_y}{dx} = k_y \underbrace{\alpha x}_{=e}$$

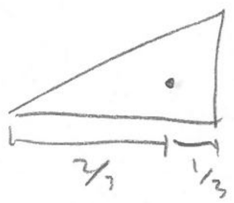
$$\frac{dF_y}{dx} = \mu \frac{W}{l_t}$$

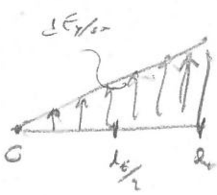
Har vi gliding?

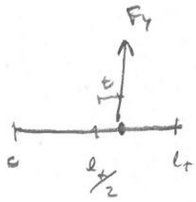
$$k_y \alpha l_t \leq \frac{\mu W}{l_t} \Rightarrow \alpha_c = \frac{\mu W}{k_y l_t^2}$$ om $\alpha \leq \alpha_c \Rightarrow$ ingen gliding

$$\alpha_c = \frac{\mu W}{k_y l_t^2} = 0{,}06378 \text{ rad} = 3{,}65^\circ > \alpha = 2^\circ$$





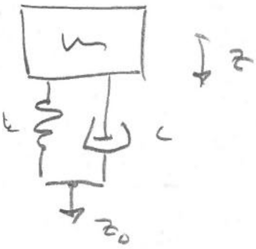


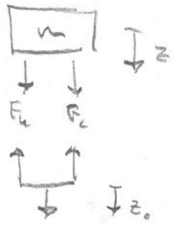


$$\frac{l_t}{2} = t + \frac{l_t}{3}$$

$$\underline{t = \frac{l_t}{6}} = 2{,}3 \text{ cm}$$

5.)





$$F_k = -k(z - z_0)$$

$$F_c = -c(\dot{z} - \dot{z}_0)$$

$$m\ddot{z} = F_k + F_c = -k(z - z_0) - c(\dot{z} - \dot{z}_0)$$

$$m\ddot{z} + c\dot{z} + kz = c\dot{z}_0 + kz_0$$

$$z_0 = Z_0 \cos(\omega t) \quad , \quad Z_0 = 0{,}012 \text{ m}$$

$$\omega = 2\pi \cdot \frac{v}{L} = 6{,}98 \text{ rad/s}$$

Laplace: $z \to \tilde{z}$, $z_0 \to \tilde{z}_0$

$$ms^2\tilde{z} + cs\tilde{z} + k\tilde{z} = cs\tilde{z}_0 + k\hat{z}_0$$

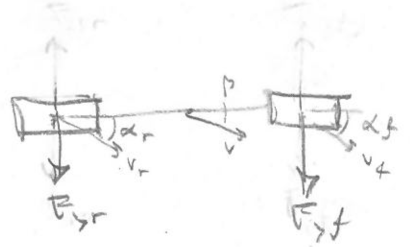
$$\tilde{z} = \underbrace{\frac{cs + k}{ms^2 + cs + k}}_{G(s)} \tilde{z}_0$$

$$z_1 = Z_1 \cos(\omega t)$$

$$Z_1 = |G(i\omega)| Z_0 = \underbrace{\left| \frac{ic\omega + k}{-m\omega^2 + ic\omega + k} \right|}_{= 1{,}64} \cdot Z_0 = 19{,}75 \text{ mm}$$

6.)

a)

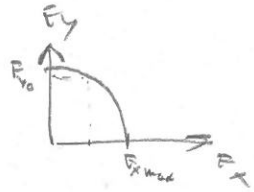


$\alpha_f = \alpha_r = \beta$

$F_y(\alpha = 4°) \approx 1900\ N$ $\left\{ \begin{array}{l} F_{yf} = -2F_y \\ F_{yr} = -2F_y \end{array} \right.$

$$I_z \dot{\Omega}_z = F_{yf} \cdot l_1 - F_{yr} \cdot l_2 = -2F_y \cdot (l_1 - l_2) = \underline{\underline{-380\ Nm}}$$

b)



$$\left(\frac{F_y}{F_{y0}}\right)^2 + \left(\frac{F_x}{F_{xmax}}\right)^2 = 1$$

$$F_y = F_{y0} \cdot \sqrt{1 - \underbrace{(F_x/F_{xmax})}_{=0,5}{}^2} = F_{y0} \cdot \sqrt{1 - 0{,}5^2} = 0{,}866$$

$$F_{yr} = -2 \cdot F_y(\alpha = 4°) \cdot \sqrt{1 - 0{,}5^2} = -3291\ N$$

$$I_z \cdot \dot{\Omega}_z = F_{yf}\, l_1 - F_{yr} \cdot l_2 = \underline{\underline{-333\ Nm}}$$

7.)

a) $$K_{us} = \frac{W_f}{2C_{\alpha f}} - \frac{W_r}{2C_{\alpha r}} = \frac{mg}{L}\left(\frac{l_2}{2C_{\alpha f}} - \frac{l_1}{2C_{\alpha r}}\right) = \frac{mg}{2L\,C_\alpha}\left(l_2 - l_1\right) =$$

$$= 0{,}00436$$

b) $$G_{yaw} = \frac{\Omega_z}{\delta}$$

$$\Omega_z = \frac{V}{R}$$

$$\delta = \frac{L}{R} + \alpha_f - \alpha_r = \dots = \frac{L}{R} + \frac{a_y}{g} K_{us} = \frac{L}{R} + K_{us} \cdot \frac{V^2}{gR}$$

$$G_{yaw} = \frac{V}{L + K_{us}\frac{V^2}{g}}$$

$$\frac{dG_{yaw}}{dV} = \frac{1 \cdot \left(L + K_{us}\frac{V^2}{g}\right) - V \cdot \frac{K_{us}}{g} \cdot 2V}{\left(L + K_{us}\frac{V^2}{g}\right)^2}$$

$$\frac{dG_{yaw}}{dV} = 0 \implies L + \cancel{K_{us}\frac{V^2}{g}} - \cancel{2} K_{us}\frac{V^2}{g} = 0$$

$$V_{char} = \sqrt{\frac{Lg}{K_{us}}} \approx 77{,}98 \ m/s$$

$$G_{yaw}^{max} = G_{yaw}(V = V_{char}) = \underline{\underline{14{,}4 \ 1/s}}$$