① a) $\dot{x} = ax$

$\frac{dx}{dt} = ax$

$\int \frac{dx}{dt} = \int ax$

$\int \frac{dx}{x} = \int a\,dt$

$\ln x = at + C$

$x = e^{at} \cdot e^{C}$

$x = Ce^{at}$

$x(0) = Ce^{a\cdot 0} = x_0$

$C = x_0$

$x(t) = x_0 e^{at}$

b) $T = -\frac{1}{a}$

$x_0 e^{at} = \frac{1}{2} x_0$

$at = \ln\frac{1}{2}$

$t_{\frac{1}{2}} = \frac{1}{a} \cdot \ln\frac{1}{2}$

$t_{\frac{1}{2}} = \underline{T \ln 2}$

c) $\dot{x} = ax + v$

sett $\dot{x} = 0$

$ax + v = 0$

$K = \frac{x}{v} = -\frac{1}{a} = T = \frac{\tau_{1/2}}{\ln 2} = \frac{1}{\ln 2} \cdot 138 = \underline{1,72 \cdot 10^3 s}$

d) $K = \frac{x_S}{v} \Rightarrow v = \frac{x_S}{K} \frac{10}{1,72 \cdot 10^7} = 5,81 \cdot 10^{-7}$

② a) Newton kraftbalanse, 2. lov

b) $v = k_p(v_r - y)$ Monovariabel og ulineær

c) $V(n) = V(n-1) + h \cdot \left(\frac{1}{m}\right) \cdot \left((k_p \cdot (v_r - V(n-1)) - k \cdot v(n-1) - k_{-1} \cdot v(n-1)^{+2}\right)$

d) $m\dot{v} = -kv + k_p v_r - k_p v$

$v(k + k_p) = k_p v_r$

$v = \frac{k_p}{k + k_p} v_r$

$e_s = \left(v_r - \frac{k_p}{k+k_p} v_r\right) = \left(1 - \frac{k_p}{k+k_p}\right) v_r = \underline{\frac{k}{k+k_p} v_r}$

③ a) $\dot{\phi} = p$

$J\dot{p} = k_1 p + k_2 \phi + v$

$v = 0$

$J\ddot{\phi} = k_1 \dot{p} + k_2 \dot{\phi}$

$\ddot{p} - \frac{k_1}{J}\dot{p} - \frac{k_2}{J} p = 0$

$\omega_0^2 = \frac{-k_2}{J}$

$\omega_0 = \sqrt{-\frac{k_2}{J}} = \sqrt{-\frac{-8,9 \cdot 10^8}{1,4 \cdot 10^{10}}} = 0,252$

$2\omega_0 \zeta = -\frac{k_1}{J}$

$\zeta = \frac{-k_1}{2\omega_0 J} = \frac{-1,3 \cdot 10^9}{2 \cdot 0,252 \cdot 1,4 \cdot 10^{10}} = \underline{0,213}$

b) $p^2 + 0,213 \cdot 0,252 \cdot 2 \cdot p + 0,252^2 = 0$

$p^2 + 0,107p + 0,064 = 0$

$\sqrt{0,107^2 - 4 \cdot 0,064} = \sqrt{-0,25}$

Underdempet

c) $\ddot{p} - \frac{k_1}{J}\dot{p} + \left(\frac{k_p \cdot k_2}{J}\right) p = 0$

$\omega_0^2 = \frac{|k_p - k_2|}{J}$

$\omega_0 = \sqrt{\frac{|k_p - k_2|}{J}} = \sqrt{\frac{5 \cdot 10^7 + 8,9 \cdot 10^8}{1,4 \cdot 10^{10}}} = 0,254$

$\frac{0,254 - 0,252}{0,252} = \underline{2,78\%}$

③ d) Ustabilitet gjennom metning

e) Vil forsuke at skipet går i sirkler og tungere dårlig med

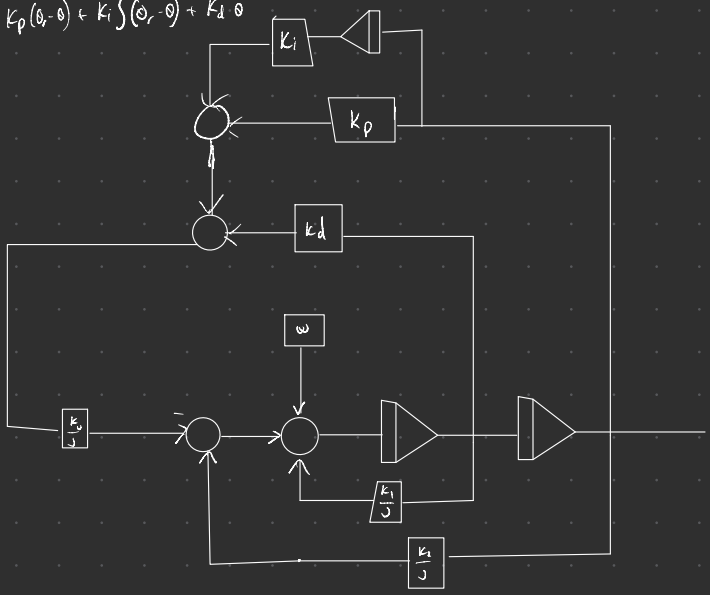
f) $\ddot{\rho} - \left(\frac{k_1 + k_p}{J}\right)\dot{\rho} - \frac{k_2}{J}\rho = 0$

$-\frac{k_1 + k_p}{J} = 2\omega_0 \zeta$

$k_p = 2\omega_0 \zeta \cdot J + k_1 = 632 \cdot 0{,}252 \cdot 1{,}41 \cdot 10^{10} - 1{,}5 \cdot 10^9 = 6{,}17 \cdot 10^8$

g) $\tau = K_p(\theta_r - \theta) + K_i \int(\theta_r - \theta) + K_d \dot{\theta}$

h)



i) Forovekobling

④ ikke pensum

⑤ a) $f_s \geq 2 f_{max}$

$f_{max} \leq \frac{f_s}{2} = \frac{10\text{kHz}}{2} = 5\text{kHz}$

b) Nedfolding er at samplingen skjer for sakte noe som medfører feil i målingene