$\dot{\Theta} = A^{-1}(\omega + nb) \Rightarrow \dot{\omega} = J^{-1}(M + u - S(\omega)J\omega)$, $\dot{h} = -u - S(\omega)h$

$a_1 = \frac{J_2 - J_3}{J_1}$, $a_3 = \frac{J_2 - J_1}{J_3} \Rightarrow a_1 - 1 = \frac{J_1 - J_2 + J_3}{J_1}$, $1 - a_3 = \frac{J_1 - J_2 + J_3}{J_3}$

$\Rightarrow (M_1 + u_1)/J_1 = \ddot{\theta}_1 + n(a_1 - 1)\dot{\theta}_3 + n^2 a_1 \theta_1$

$\Rightarrow (M_3 + u_3)/J_3 = \ddot{\theta}_3 + n(1 - a_3)\dot{\theta}_1 + n^2 a_3 \theta_3$ and apply Laplace

$T_1 = \Rightarrow \frac{M_1 + u_1}{J_1} = (s^2 + n^2 a_1)\theta_1 + sn(a_1 - 1)\theta_3$ $\frac{M_3 + u_3}{J_3} = sn(1 - a_3)\theta_1 + (s^2 + n^2 a_3)\theta_3 = T_3$

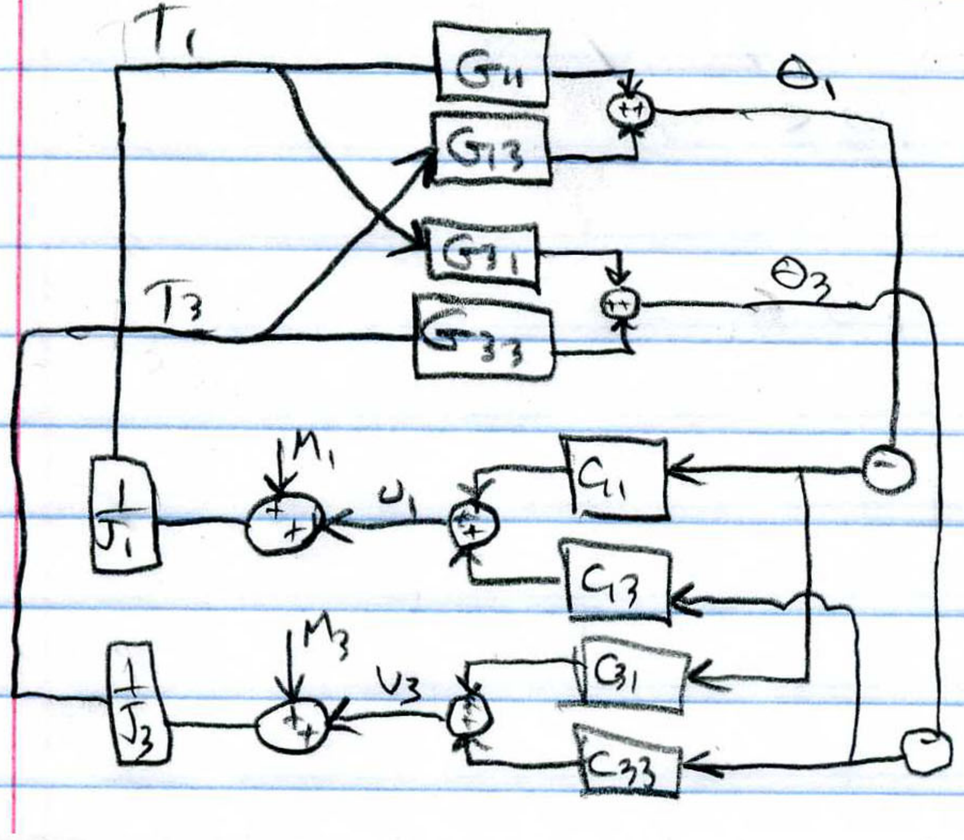
$(s^2 + n^2 a_1)(s^2 + n^2 a_3) - s^2 n^2 (a_1 - 1)(1 - a_3) = (s^2 + n^2)(s^2 + a_1 a_3 n^2)$ char. eqn. for open loop

$\Rightarrow \theta_3 = \frac{T_3 - sn(1 - a_3)}{s^2 + n^2 a_3}\theta_1 \Rightarrow T_1 = (s^2 + n^2 a_1)\theta_1 + sn(a_1 - 1)\left(\frac{T_3 - sn(1 - a_3)}{s^2 + n^2 a_3}\right)\theta_1$

$\Rightarrow T_1(s^2 + n^2 a_3) - T_3 sn(a_1 - 1) = \theta_1\left[\underbrace{(s^2 + n^2 a_1)(s^2 + n^2 a_3) - s^2 n^2 (a_1 - 1)(1 - a_3)}_{D = (s^2 + n^2)(s^2 + a_1 a_3 n^2)}\right]$

$\Rightarrow \theta_1 = \frac{s^2 + n^2 a_3}{D} T_1 + \frac{-sn(a_1 - 1)}{D} T_3 = G_{11} T_1 + G_{13} T_3 = \frac{N_{11}}{D} T_1 + \frac{N_{13}}{D} T_3$

$\Rightarrow \theta_3 = \frac{-sn(1 - a_3)}{D} T_1 + \frac{(s^2 + n^2 a_1)}{D} T_3 = G_{31} T_1 + G_{33} T_3 = \frac{N_{31}}{D} T_1 + \frac{N_{33}}{D} T_3$



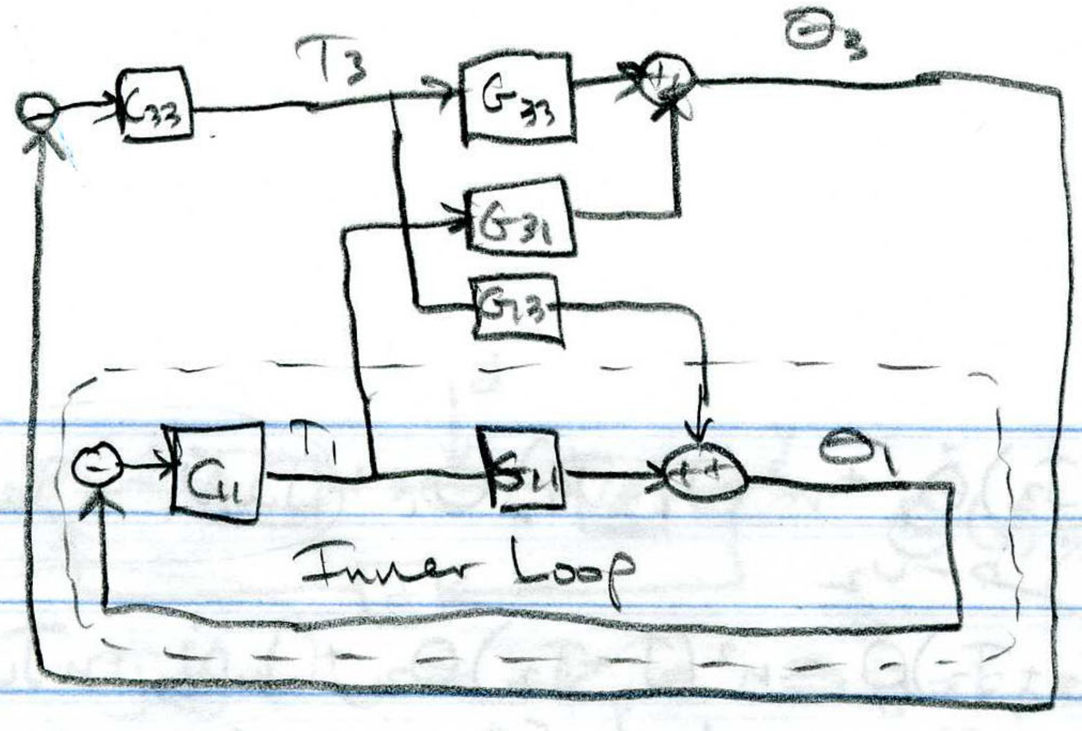
To do this by hand, kill C_{13} + C_{31}.

$\begin{bmatrix}\theta_1 \\ \theta_3\end{bmatrix} = \begin{bmatrix}G_{11} & G_{13} \\ G_{31} & G_{33}\end{bmatrix}\begin{bmatrix}T_1 \\ T_3\end{bmatrix}$

$\begin{bmatrix}u_1 \\ u_3\end{bmatrix} = \begin{bmatrix}C_{11} & \cancel{C_{13}}^{0} \\ \cancel{C_{31}}^{0} & C_{33}\end{bmatrix}\begin{bmatrix}\theta_1 \\ \theta_3\end{bmatrix} = \begin{bmatrix}C_{11} & 0 \\ 0 & C_{33}\end{bmatrix}\begin{bmatrix}\theta_1 \\ \theta_3\end{bmatrix}$

then corridor only loop that goes through θ_1.

So erase C_{13} and C_{31} and redraw the block diagram.



Stabilize inner loop first then outer loop.
Called successive loop closure