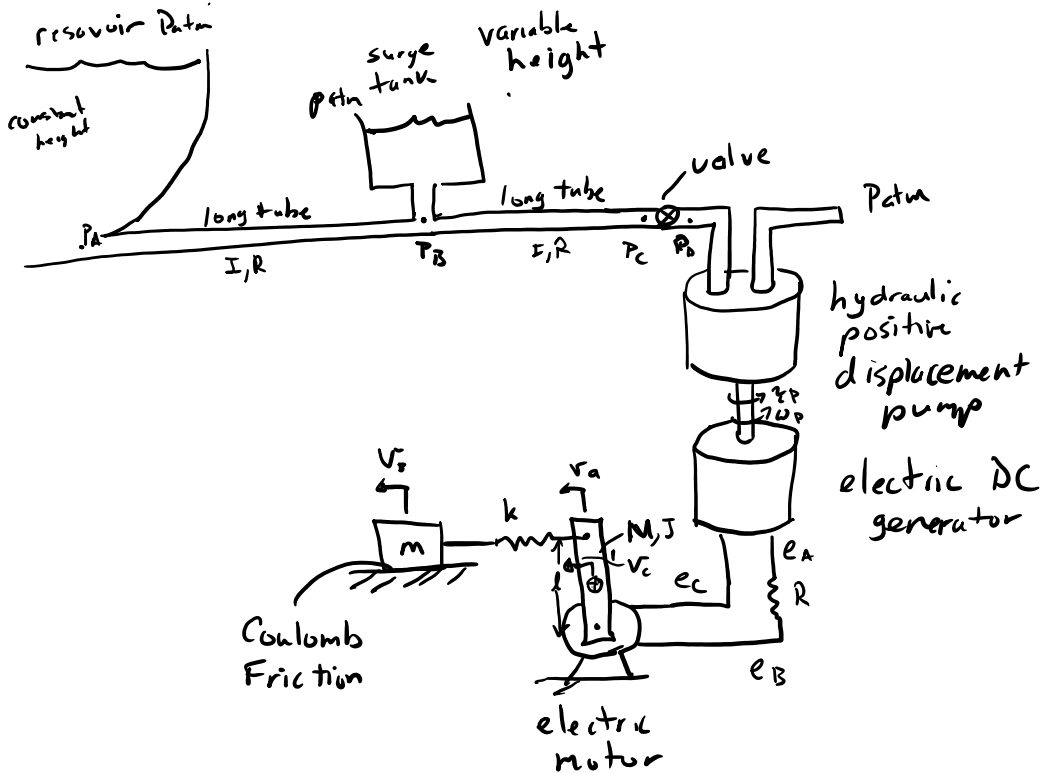


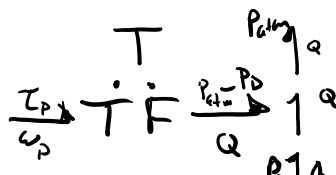
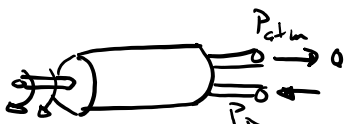
= eval.ucdavis.edu

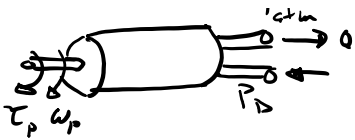
Friday, December 6, 2019 2:52 PM

- HW #9 Due Today (solutions posted in morning)
- Lab #5 Due Monday (solutions will not be posted)
- Exam Thursday Dec 12<sup>th</sup> 3:30-5:30 PM  
Same rules as mid term Chem 176 (here)
- Seating chart
- all belongings at front, except pencil/pen/eraser/dictionary/water
- Open notes: only notes you write yourself
- no electronic devices, leave phone in book bag
- show all work
- instructor will have paper
- staple extra paper to exam and indicate final solution to grade and if extra paper
- Multibody Dynamics Presentations Dec 12 1:00PM-3:00PM Wickson 1020



hydraulic pump:



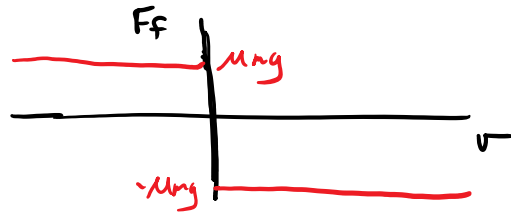


Coulomb Friction

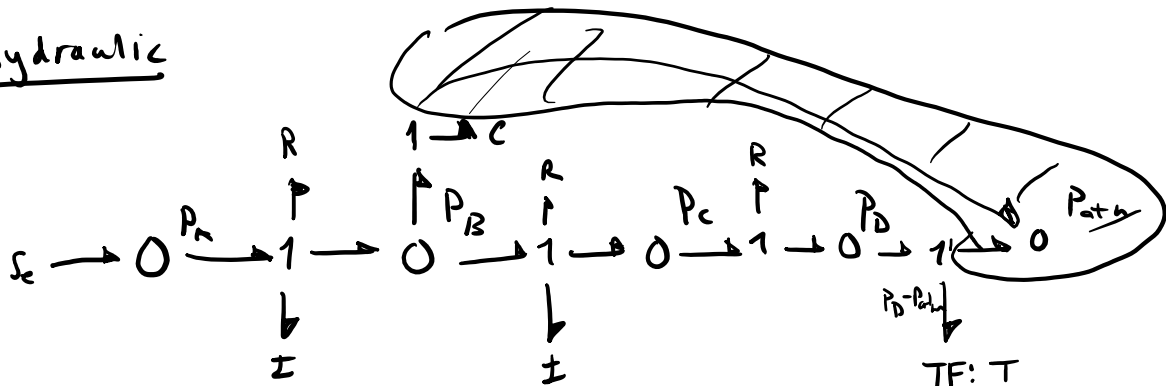
$$F_f = \mu N = \mu mg$$



$$\frac{T_p}{\omega_p} \rightarrow TF \rightarrow \frac{P_{out} = T_d}{Q} \rightarrow 1 \text{ Q}$$

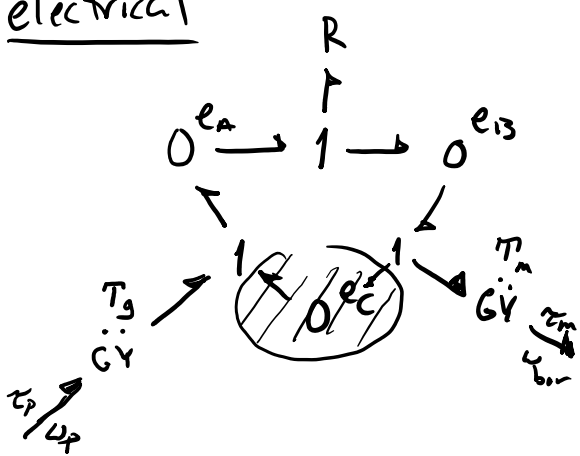


hydraulic



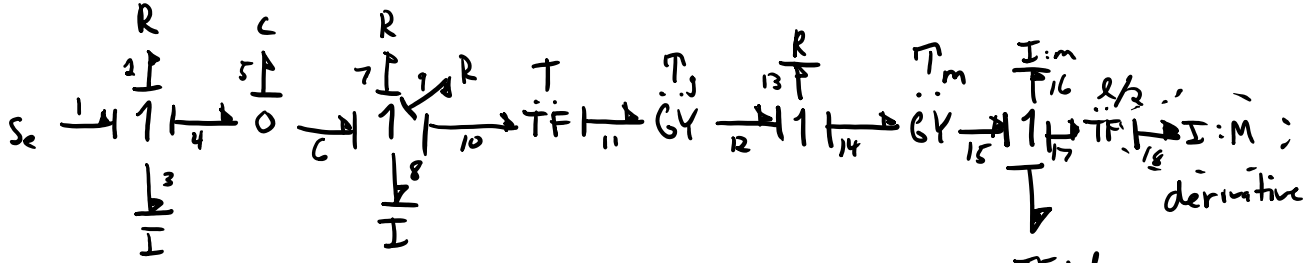
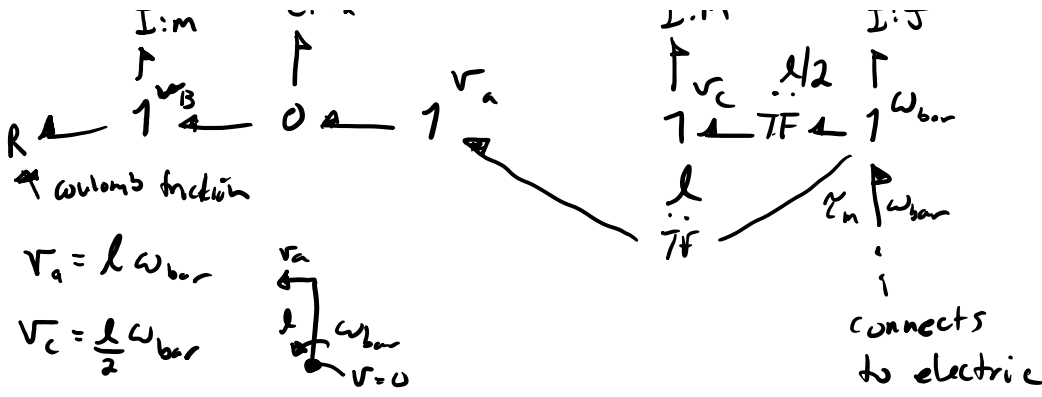
TF: T  
 $\tau_p \leftarrow \omega_p$   
 connects to the generator

electrical



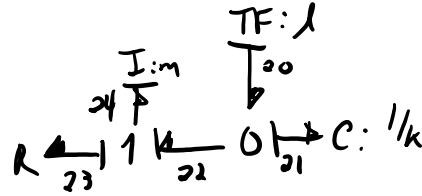
mechanical





States:  $P_3, q_5, p_8, P_{16}, q_{21}, p_{24}$  (not  $p_{14}$ !)

Inputs:  $Se_1$



Start with derivative causality: with constitutive law

$$P_{18} = I_{18} f_{18} = I_{18} \frac{1}{2} f_{17} = \frac{I_{18} l}{2} \frac{P_{16}}{I_{16}}$$

take the derivative

$$\dot{P}_{18} = \frac{l I_{18}}{2 I_{16}} \dot{P}_{16} \quad \text{will use later}$$

$$\dot{P}_3 = \dot{e}_3 = \dot{Se}_1 - \dot{e}_2 - \dot{e}_4 = \dot{Se}_1 - f_2 R_2 - \frac{q_5}{c_5} = \dot{Se}_1 - \frac{P_3}{I_3} R_2 - \frac{q_5}{c_5}$$

$$\textcircled{1} \dot{P}_3 = \dot{Se}_1 - \frac{R_2}{I_3} P_3 - \frac{q_5}{c_5}$$

$$\textcircled{2} \dot{q}_5 = \dot{f}_5 = \dot{f}_4 - \dot{f}_c = \frac{P_3}{I_3} - \frac{p_8}{I_8}$$

$$\dot{p}_8 = \dot{e}_8 = \dot{e}_c - \dot{e}_7 - \dot{e}_9 - \dot{e}_{10} = \frac{q_5}{c_5} - R_7 f_7 - R_9 f_9 - T e_{11}$$

$$\dot{p}_8 = \frac{q_5}{c_5} - R_7 \frac{p_8}{I_8} - R_1 \frac{p_8}{I_8} - T \tau_g f_{12} = \frac{q_5}{c_5} - (R_7 + R_1) \frac{p_8}{I_8} - T \tau_g f_{12}$$

$$\dot{p}_8 = \frac{q_5}{c_5} - (R_7 + R_1) \frac{p_8}{I_8} - T \tau_g \frac{e_{13}}{R_{13}}$$

$$e_{13} = e_{12} - e_{14} = \tau_g f_{11} - \tau_m f_{15} = \tau_g T \frac{p_8}{I_8} - \tau_m \frac{p_{16}}{I_{16}}$$

$$\textcircled{3} \dot{p}_8 = \frac{q_5}{c} - (R_7 + R_1) \frac{p_8}{I_8} - \frac{T \tau_g}{R_{13}} \left( \tau_g T \frac{p_8}{I_8} - \tau_m \frac{p_{16}}{I_{16}} \right)$$

$$\dot{p}_{16} = e_{16} = e_{15} - e_{17} - e_{19} = \tau_m f_{14} - l/2 e_{18} - l e_{20}$$

$$\dot{p}_{16} = \frac{\tau_m}{R_{13}} e_{13} - l/2 \dot{p}_8 - l \frac{q_{21}}{c_{21}}$$

already have above      plug in derivative causality equation here!

$$\dot{p}_{16} = \frac{\tau_m}{R_{13}} \left( \tau_g T \frac{p_8}{I_8} - \tau_m \frac{p_{16}}{I_{16}} \right) - l/2 \left( l/2 \frac{I_{18}}{I_{16}} \dot{p}_{16} \right) - l \frac{q_{21}}{c_{21}}$$

solve for  $\dot{p}_{16}$

$$\textcircled{4} \dot{p}_{16} = \frac{\tau_m}{R_{13}} \left( \tau_g T \frac{p_8}{I_8} - \tau_m \frac{p_{16}}{I_{16}} \right) - l \frac{q_{21}}{c_{21}}$$

$$1 + \frac{l^2}{4} \frac{I_{18}}{I_{16}}$$

$$\textcircled{5} \dot{q}_{29} = f_{29} = f_{20} - f_{22} = l f_{19} - \frac{p_{24}}{I_{24}} = l \frac{p_{16}}{I_{16}} - \frac{p_{24}}{I_{24}}$$

$$\textcircled{6} \dot{p}_{24} = e_{24} = e_{22} - e_{23} = \frac{q_{21}}{c_{21}} - h(f_{23})$$

↑ Coulomb friction function (non-linear)

if viscous friction  $e_{23} = R_{23} f_{23}$

$$\dot{p}_{24} = \frac{q_{21}}{c} - R_{23} f_{23} = \frac{q_{21}}{c} - R_{23} \frac{p_{24}}{I_{24}}$$

$$\dot{p}_{24} = \frac{q_{21}}{c_{21}} - R_{23} f_{23} = \frac{q_{21}}{c_{21}} - R_{23} \frac{p_{24}}{I_{24}}$$