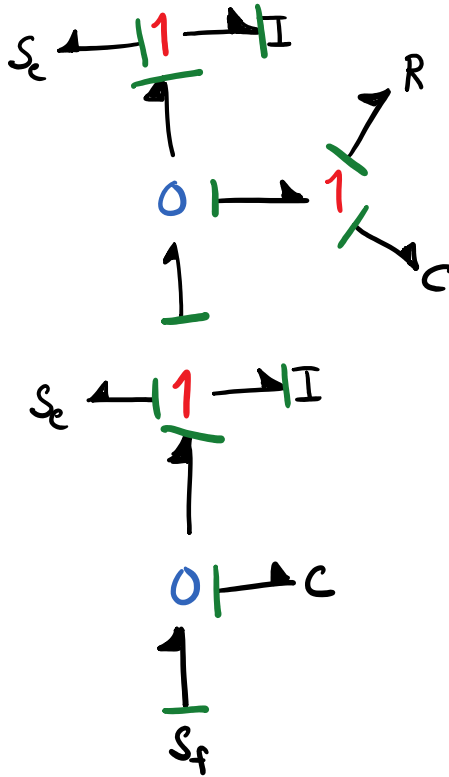


# HW #8 Due Monday March 2

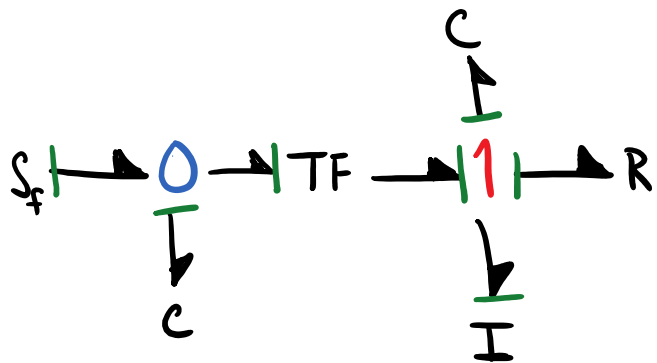
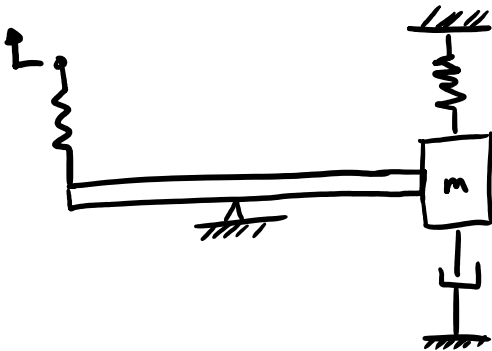
## Steps to assigning causality to a system model

1. choose a  $S_e$  or  $S_f$  and assign causality
2. extend causality through TF, GY, O, 1 as far as possible
3. repeat 1 + 2 for all  $S_e$  and  $S_f$
4. select an I or C and assign the preferred causality (if possible)
5. extend causality through TF, GY, O, 1 as far as possible
6. repeat 4 + 5 for all I's and C's.
7. it is common that causality is complete, check for completeness and stop if so, or if not continue to step 8
8. choose any R and assign an arbitrary causality
9. extend causality through TF, GY, O, 1 as far as possible
10. repeat 8 + 9 for all R.
11. check for completeness, stop or move on to 12
12. choose any remaining bond without causality and assign an arbitrary causality
13. extend . . . .
14. repeat 12 + 13 until complete

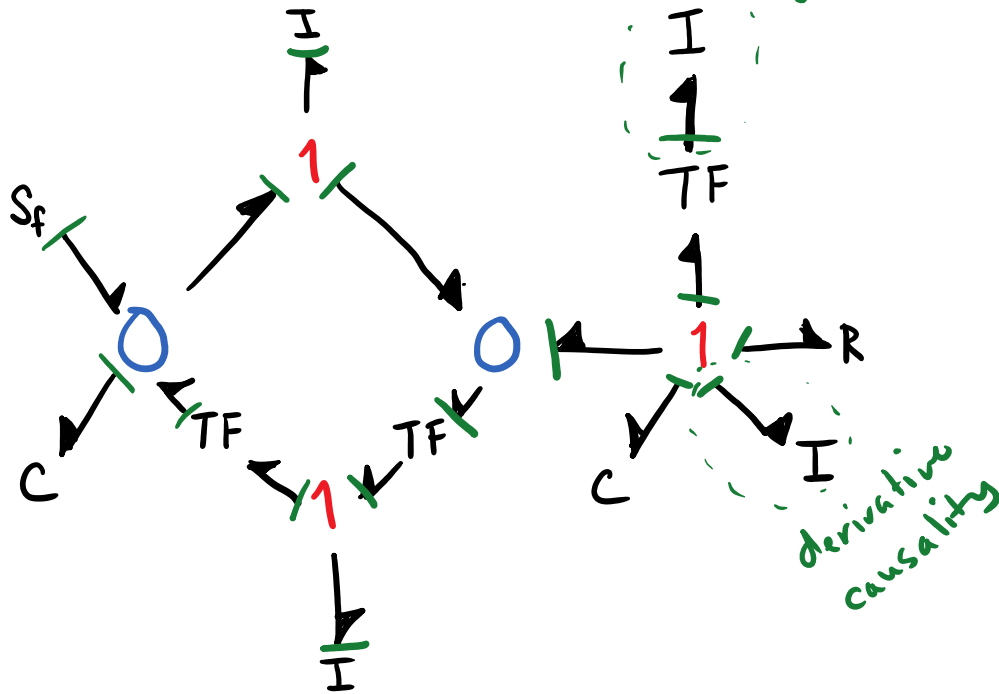
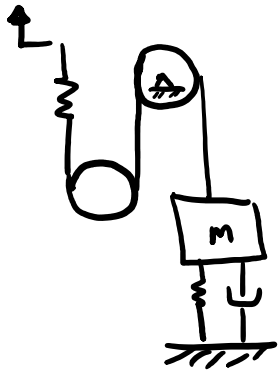
Example



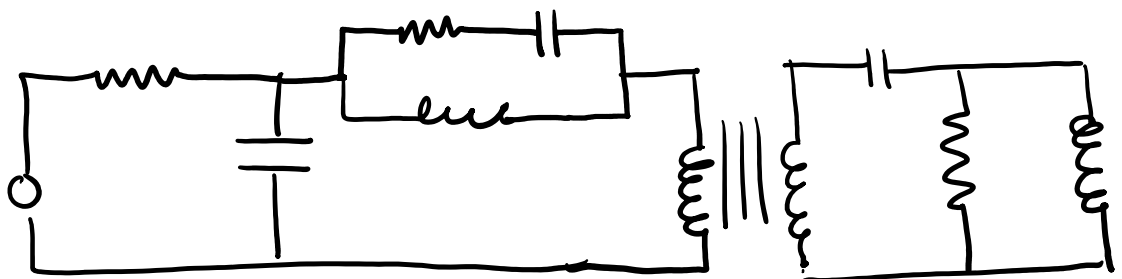
Example



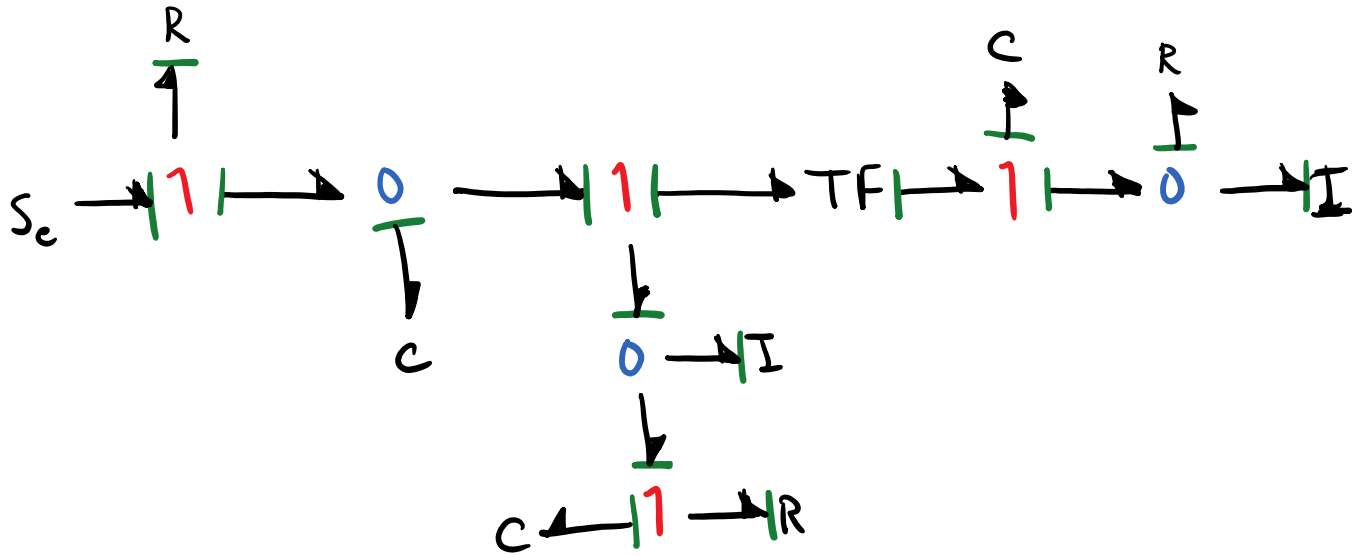
# Exercise



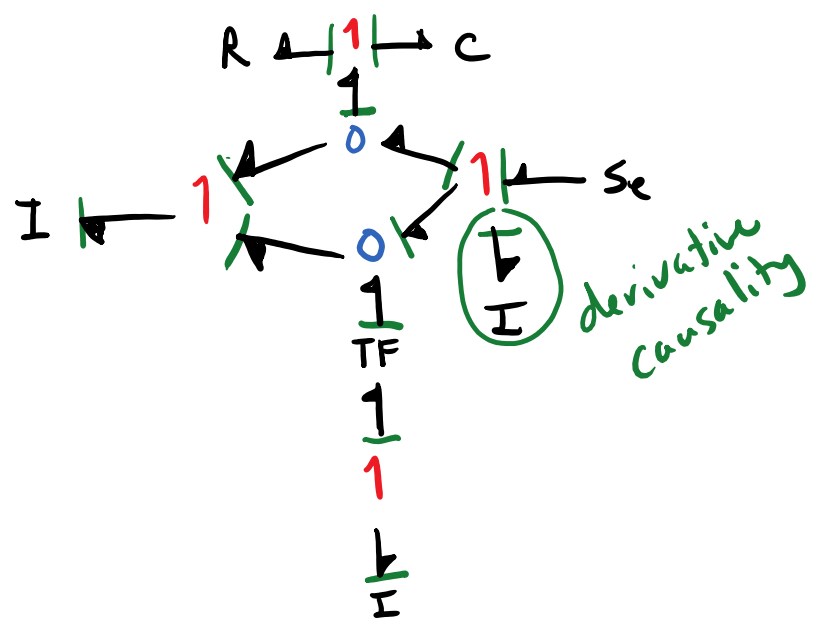
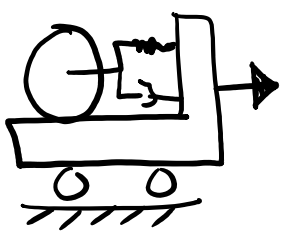
# Exercise



D



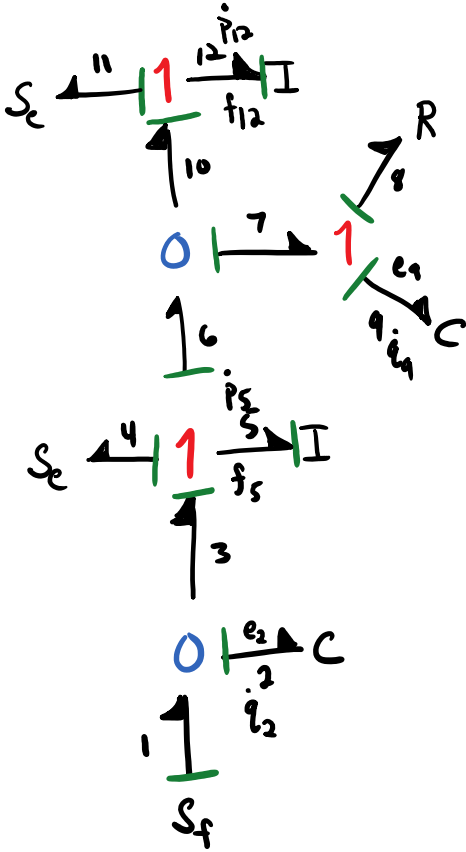
Example



## Forming System Equations

1. number each bond
2. define the state variables:  $p$ 's and  $q$ 's of I and C ports that have integral causality
3. write  $\dot{p}, f$  and  $\dot{q}, e$  for each I and C
4. start with lowest # bond I and C and write  
 $\dot{p} = e$  or  $\dot{q} = f$
5. follow causality for  $e$  or  $f$  to I, C, R
6. write constitutive law for non-state variables

# Quarter Car Model 1



State variables:  $q_2, p_5, q_9, p_{12}$

Inputs:  $S_{f1}, S_{e4}, S_{e11}$

- ①  $\dot{q}_2 = f_2$
- ②  $\dot{p}_5 = e_5$
- ③  $\dot{q}_9 = f_9$
- ④  $\dot{p}_{12} = e_{12}$

①  $\dot{q}_2 = f_2 = f_1 - f_3 = S_{f1} - f_5$

$q_2 = S_{f1} - \frac{p_5}{I_5}$

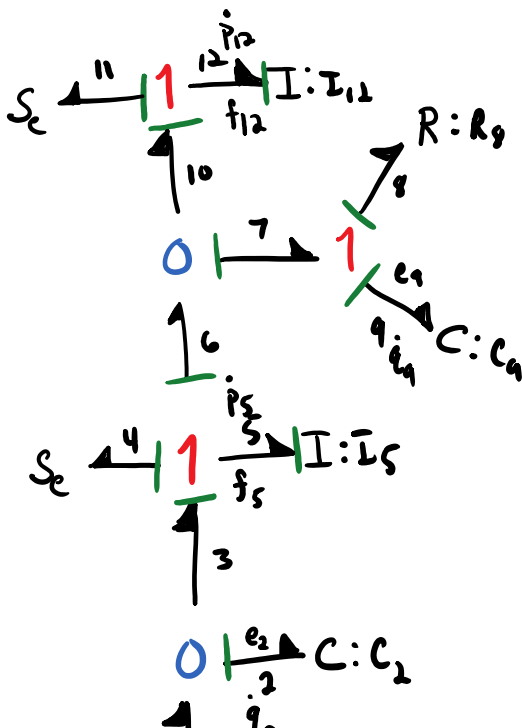
②  $\dot{p}_5 = e_5 = e_3 - e_4 - e_6 = e_2 - S_{e4} - e_7$

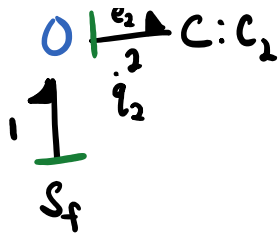
$\dot{p}_5 = \frac{q_2}{c_2} - S_{e4} - (e_8 + e_9)$

$\dot{p}_5 = \frac{q_2}{c_2} - S_{e4} - (R_9 f_9 + \frac{q_9}{c_9})$

$\dot{p}_5 = \frac{q_2}{c_2} - S_{e4} - (R_9 [f_c - f_{10}] + \frac{q_9}{c_9})$

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$$\dot{P}_5 = \frac{q_2}{C_2} - S_{14} - \left( R_8 \left[ \frac{P_5}{I_5} - \frac{P_{12}}{I_{12}} \right] + \frac{q_9}{C_9} \right)$$

$$\textcircled{3} \quad \dot{q}_9 = f_9$$