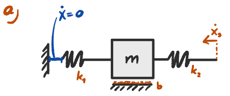
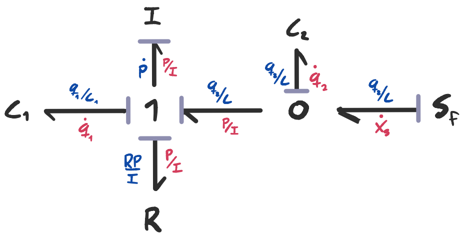
TEP4240
System Simulation
Exercise 4

Mechanical Translatoric

a)

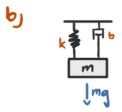


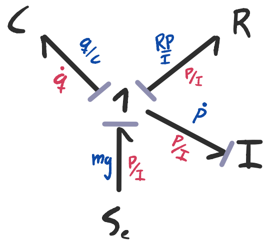


$$
\begin{bmatrix} \dot{q}_2 \\ \dot{q}_1 \\ \dot{p} \end{bmatrix} = \begin{bmatrix} \dot{x}_s - \frac{P}{I} \\ -\frac{P}{I} \\ \frac{q_2}{C_2} - \frac{q_1}{C_1} - \frac{RP}{I} \end{bmatrix}
$$

Order of the system: 3

b)



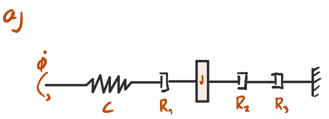


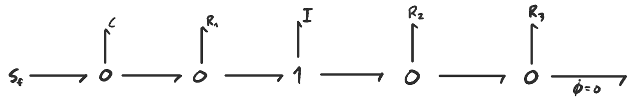
$$
\begin{bmatrix} \dot{q} \\ \dot{p} \end{bmatrix} = \begin{bmatrix} \frac{P}{I} \\ mg - \frac{RP}{I} - \frac{q}{C} \end{bmatrix}
$$

Order of the system: 2

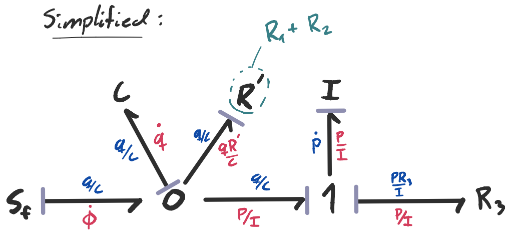
Mechanical Rotational

a)





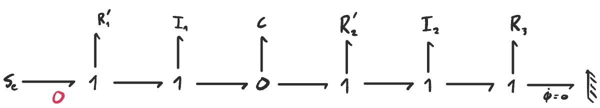
Simplified:



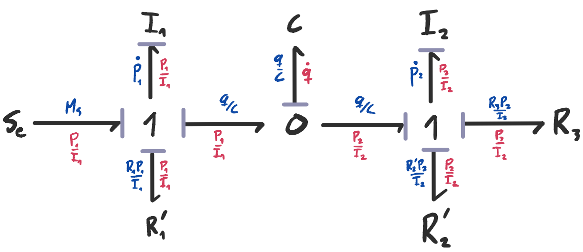
Order of the system: 2

$$
\Rightarrow \begin{bmatrix} \dot{p} \\ \dot{q} \end{bmatrix} = \begin{bmatrix} \frac{q}{C} - \frac{PR_3}{I} \\ \dot{\phi} - \frac{q}{C}(R_1+R_2) - \frac{P}{I} \end{bmatrix}
$$

c) Let the two resistances be set to a $R_1' : 2b_1$ and $R_2' : 2b_2$ since flow is same on both sides of each mass.



Simplified:

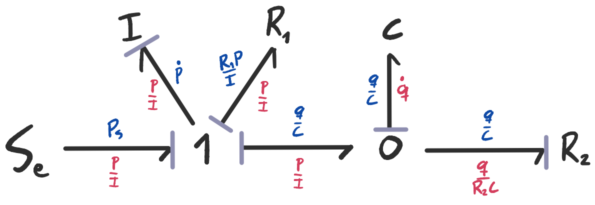


$$
\begin{bmatrix} \dot{p}_1 \\ \dot{p}_2 \\ \dot{q} \end{bmatrix} = \begin{bmatrix} M_s - \frac{R_1 P_1}{I_1} - \frac{q}{C} \\ \frac{q}{C} - \frac{R_3 P_2}{I_2} - \frac{R_2' P_2}{I_2} \\ \frac{P_1}{I_1} - \frac{P_2}{I_2} \end{bmatrix}
$$

Order of the system: 3

Fluid

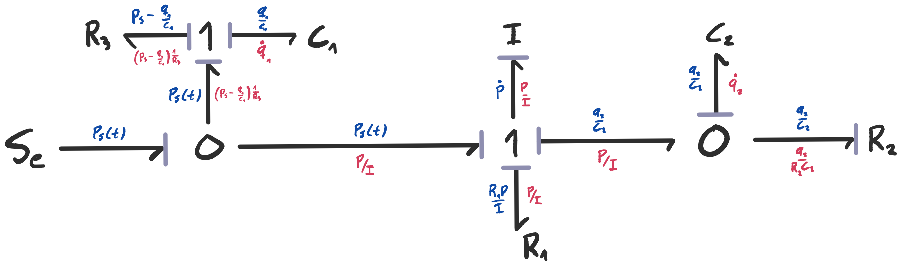
a)



$$\Rightarrow \begin{bmatrix} \dot{q} \\ \dot{p} \end{bmatrix} = \begin{bmatrix} \frac{p}{I} - \frac{q}{R_2 C} \\ P_s - \frac{q}{C} - \frac{R_1 p}{I} \end{bmatrix}$$

Order of the system: $\underline{\underline{2}}$

d)



$$\Rightarrow \begin{bmatrix} \dot{q}_1 \\ \dot{q}_2 \\ \dot{p} \end{bmatrix} = \begin{bmatrix} \frac{1}{R_3}\left(P_s(t) - \frac{q_1}{C_1}\right) \\ \frac{p}{I} - \frac{q_2}{R_2 C_2} \\ P_s(t) - \frac{R_1 p}{I} - \frac{q_2}{C_2} \end{bmatrix}$$

(Order 3) Where P_s is gauge pressure for the pump.

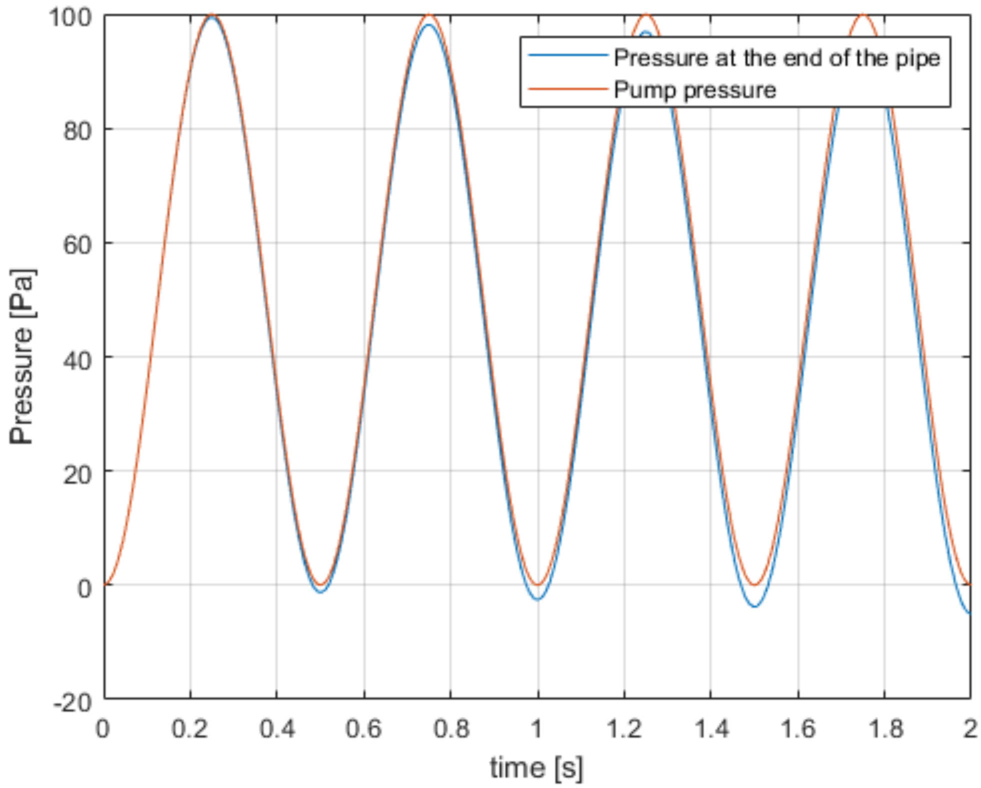
For the simulation:

$$C_1 = \frac{A_1}{\rho g} \qquad R_1 = b_1$$

$$C_2 = \frac{A_2}{\rho g} \qquad R_2 = b_2$$

$$I = \frac{\rho L}{A_c} \qquad R_3 = b_3$$

```
clc
close all
clear all

% Differential equations for Fluid system d)
%   q1_dot = 1/R3 * (Ps - q1/C1)
%   q2_dot = P/I - q2/(R2*C2)
%   p_dot  = Ps  - R1*P/I - q2/C2

% Constants:
rho =  1000;            % kg/m3
g   =  9.81;            % m/s2
A1  =  pi*(0.3)^2;     % m2
A2  =  pi*(0.3)^2;     % m2
Ac  =  pi*(0.5)^2;    % m2
b1  =  10;               % Ns/m
b2  =  1000;               % Ns/m
b3  =  1000;              % Ns/m
L   =  15;              % m

% Definitions
R1  =  b1;
R2  =  b3;
R3  =  b3;
I   =  rho*L/Ac;
C1  =  A1/(rho*g);
C2  =  A2/(rho*g);

% Initial conditions
q1_0 = 0; q2_0 = 0; p_0  = 0;
y0  = [q1_0 q2_0 p_0];

%[t, Y] = ode45(@odefun_ex4,[0 40],y0);
[t, Y] = ode45(@(t, y) odefun_ex4(t, y, I, C1, C2, R1, R2, R3), ...
    [0 2], y0);
q1 = Y(:,1); q2 = Y(:,2); p  = Y(:,3);

Ps = 100*(sin(2*pi*t)).^2;

q1_dot = 1/R3 * (Ps - q1/C1);
q2_dot = p/I - q2/(R2*C2);
p_dot  = Ps  - R1*p/I - q2/C2;

plot(t,p_dot, t,Ps);
legend('Pressure at the end of the pipe', 'Pump pressure' )
xlabel('time [s]')
grid on
ylabel('Pressure [Pa]')
```



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```
function dydt = odefun_ex4(t, y, I, C1, C2, R1, R2, R3)
    % Extract variables from the y vector
    q1 = y(1);
    q2 = y(2);
    p  = y(3);

    t;
    Ps = 100*(sin(2*pi*t)).^2; % Pascals

    % Define the system of ODEs
    q1_dot = 1/R3 * (Ps - q1/C1);
    q2_dot = p/I - q2/(R2*C2);
    p_dot  = Ps  - R1*p/I - q2/C2;

    % Pack the derivatives into a column vector
    dydt = [q1_dot; q2_dot; p_dot];
end
```

```
Not enough input arguments.

Error in odefun_ex4 (line 4)
    q1 = y(1);
```

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