Sensors and Control for Mechatronics Systems
Tutorial 6

Question 1 : The state space model

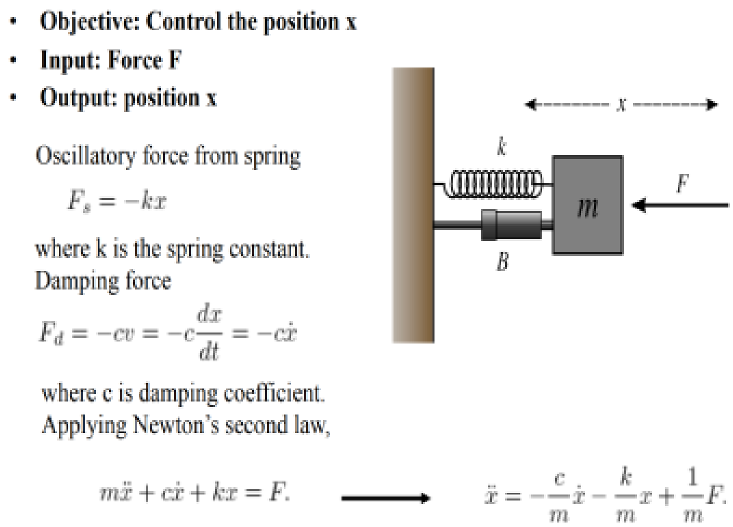
Consider the state space model for A = [-3 0; 0 1], B = [0; 1]. Using hand calculation;

1.1 : Compute the eigenvalues of A. Is the system stable?

1.2 : Check the system controllability.

1.3 : Perform pole placement to place the poles at -3, -4.

Question 2 : Mass-spring-damper system



2.1 : Define the state vector for the following system

2.2 : Define matrices A, B, C, D for the state space model

2.3 : For m = 1000 kg, k = 50 kgs-2, and c = 20 kgs-1, use the Matlab function ***ss*** to create a state-space model of the open loop system.
Ref. : https://au.mathworks.com/help/control/ref/ss.html

2.4 : Plot the step response of the open loop system using ***step*** function.
https://au.mathworks.com/help/control/ref/step.html

2.5 : Use poles [-0.1 -0.3] and compute the gain matrix K using the Matlab function ***place***, to stabilise the system using pole placement.
Ref. : https://au.mathworks.com/help/control/ref/place.html

2.6 : Using the state feedback control law ***u(t) = -Kx(t)***, create the state-space model for the closed loop system.

2.7 : Use the ***dcgain*** function to scale the system appropriately.

Question 3 : LQR control

3.1 : Consider a rotating mass in a frictionless space with the following system equations, design the state feedback control ***u(t) = -Kx(t)*** such that the performance index

$J = \int_0^{\infty} (x^T Q\, x + u^T R\, U)\, dt$ is minimized.

A = [0 1; 0.01 0]
B = [0; 1]
C = [1 0];
D = 0;
Q = [1 0; 0 1]
R = 1

Download the helper code and complete it to observe the effect Q and R has on the system when starting from the initial conditions x0= [3;0] to bring the system to equilibrium stat x=[0;0]

For this purpose use Matlab function ***lqr*** to calculate the optimal gain matrix ***K*** and use this gain matrix K to create a closed loop system
Ref. : https://au.mathworks.com/help/control/ref/lqr.html

Question 4 : Inverted Pendulum

4.1 : Simulate the state-space model of the inverted pendulum system ***(refer to the notes provided for the model)***. Use the following values for M, m, l and g.

m=0.1;
M=2;
l=0.5;
g=9.81;

4.2 : Check the system stability.

4.3 : Check the system controllability.

4.4 : Perform pole placement to place the poles to be [-1 -2 -3 -4].

4.5 : Design LQR control using Q = I_4 (Identity matrix of dimension 4) and R = 1.

4.6 : Compute and plot the state and control inputs for the arbitrarily placed poles and the optimal control solution.