<u>TD3 – State Space Representation</u>

Problem 1. Express the state space equation of following transfer function

$$H(s) = \frac{Y(s)}{U(s)} = K_p + \frac{K_i}{s} + \frac{K_d N s}{s+N}$$

Where, K_p, K_i, K_d, N are constants

Problem 2. Given a process described by a sinusoid movement. This process may be e.g. a disturbance, like waves and temperatures. Let

$$y(t) = \sin(\omega t + \phi)$$

A sinusoid disturbance is common in many processes. This example is therefore of importance when modeling disturbances. Write a state space description of the sinusoid process.

Problem 3. Consider a system described be the following couple of differential equations

$$\begin{aligned} \ddot{z} - 4\ddot{v} + 2\dot{e} + v &= -\dot{u}_1 + 2u_2 \\ \dot{e} - 2\dot{v} + z &= u_1 \\ \ddot{v} + e &= u_1 + u_2 \end{aligned}$$

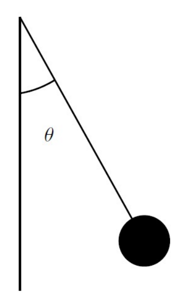
Where u_1 and u_2 are defined as control inputs and e and v are defined as measurement or output.

Obtain the state space model of system.

Problem 4. The nonlinear dynamic equation for a pendulum is given by

$$ml\ddot{\theta} = -mg\sin\theta - kl\dot{\theta}$$

Where l the length of the pendulum is, m is the mass of the bob, and θ is the angle subtended by the rod and the vertical axis through the pivot point,



a) Choose appropriate state variables and write down the state equations.
b) Find all equilibria of the system.
c) Linearize the system around the equilibrium points, and determine whether the system equilibria are stable or not.

Problem 5. A synchronous generator connected to an infinite bus can be modeled by

$$M\ddot{\delta} = P - D\dot{\delta} - \eta_1 E_p \sin\delta$$
$$\tau\dot{E}_p = -\eta_2 E_p + \eta_3 \cos\delta + E_{FD}$$

where δ is the angle in radians, E_p is voltage, P is mechanical input power, E_{FD} is field voltage (input), D is damping coefficient, M is inertial coefficient, τ is a time constant, and η_1, η_2, and η_3 are constant parameters.

a) Using $\delta, \dot{\delta}$, and E_p as state variables, find the state equation.

b) Linearize the system around $\delta = 1, E_p = 2$ under control input $P = 0, E_{ED} = 4$
$M = 1, D = 0.1, \tau = 0.2, \eta_1 = 0.5, \eta_2 = 1, \eta_3 = 2$