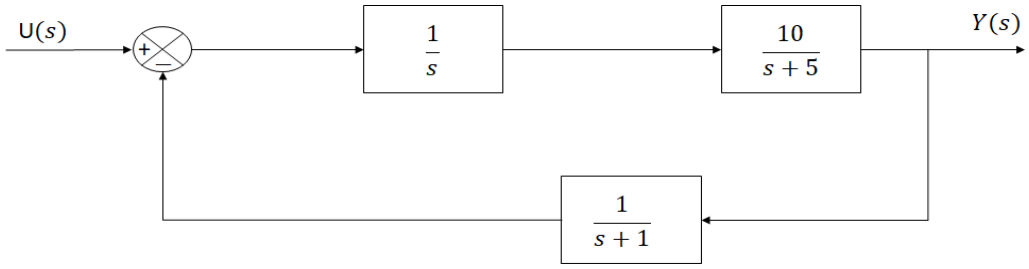
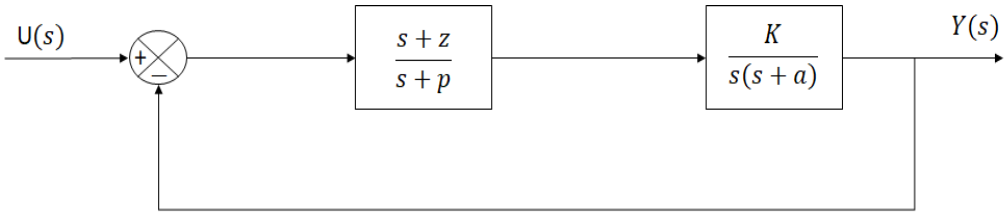
ME311: Micro-Processors and Controls
Tutorial Problem Set 4 (Max Points: 25)

1. [3 Points] Obtain a state-space description of a system, whose block diagram is given below. [Hint: Choose the output of each of the three blocks to be a state.]

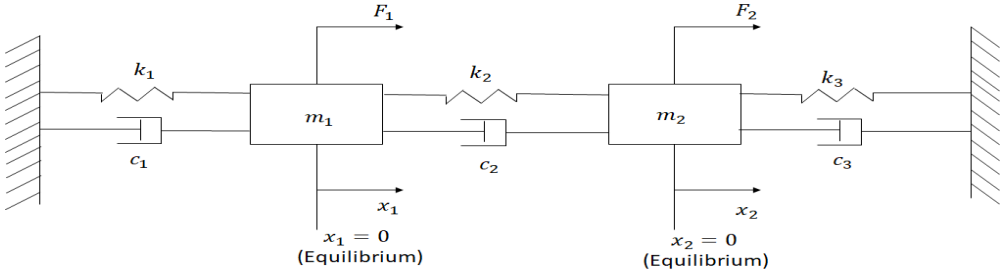


2. [5 Points] The general technique of getting state-space descriptions from a block diagram in Laplace domain is to write the block diagram such that each block has at most a first order polynomial in the denominator and a constant in numerator. Then, assume that output of each such block as a state and write down input output equations of each block and simplify. Use this technique to get state-space form for the following block diagram.



3. [2 Points] The impulse response of the system is given by
$$h = -te^{-t} + 2e^{-t}; t > 0.$$
What will be the transfer function?

4. [4 Points] For the mechanical system shown below F_1 and F_2 are two inputs and x_1 and x_2 are the variables of interest. Write down the state-space description of this system.



5. [6 Points] Show the linearity/non-linearity and time invariance/variance properties of the following systems.
   (a) $\dot{y}(t) = au(t) + b$
   (b) $\dot{y}(t) + ay(t) = bt\dot{u}(t)$
   (c) $\dot{y}(t) + (y(t))^2 = u(t)$

6. Consider the spring-mass-damper system shown below with x being the output.
   (a) [2 Points] Write down the dynamics in second order form and find the transfer function.

(b) [2 Points] Write the state-space description of this system. Find the transfer function by taking Laplace Transform of state-space equations and show that it matches the transfer function derived in part (a) above.

(c) [1 Point] Is the system BIBO stable? Why or why not?