Exercise Sheet 1

Problem 1:

We want to learn basics about Matlab and Simulink. We look at the following differential equations with their corresponding transfer functions

$$4\,\dot{y} + y = 10\,u \qquad G_1(s) = \frac{10}{4\,s+1}$$
$$5\,\ddot{y} + 2\,\dot{y} + y = 5\,u \qquad G_2(s) = \frac{5}{5\,s^2+2\,s+1}$$
$$5\,y^{(3)} + 2\,\ddot{y} + \dot{y} = 5\,u \qquad G_3(s) = \frac{5}{5\,s^3+2\,s^2+s}$$

We want to use Matlab/Simulink to simulate the response of the above transfer functions to different input signals.

a. Open an m-file and create transfer function models of G_1, G_2, G_3

Hint: Use `s = tf('s')` and the standard math operators $+$, $\cdot$, $/$, $-$

b. The step response of an LTI system is defined as the output signal if a unit step signal is applied at the input. Determine the step response of the transfer functions.

Hint: Use the function `step`. Write "`help step`" in the Matlab command window to get help on this function.

c. Perform the same task as in **b.** in Simulink. Open the simulink library browser and use the relevant transfer blocks. For the transfer functions, you should look at the `Continuous/Transfer Fcn` block. For the step input, you need the `Sources/Step` block. For output measurement, you need the `Sinks/Scope` block.

d. Simulate G_2 with a ramp input. What do you observe in comparison with the step response of G_3?

e. Simulate G_2 and G_3 with a sinusoidal input signal (frequency 0.5 rad/sec). What do you observe for the output signal?

Problem 2:

The following ordinary differential equations are given.

(i) $5y^{(2)} + 3u^{(5)} - 7y^{(3)} + y - 2u^{(1)} = 2u^{(2)}$

(ii) $y^{(4)} - 2ty^{(2)} + 4u^{(2)} = 0$

(iii) $yu - 2y^{(2)} + 4y - u = 0$

(iv) $\dot{y} + 0.5x = 3\dot{u} - u$ and $\dot{y} + \dot{x} - 3y = 4\dot{u}$

(v) $y^{(3)} + u - \dot{u} + y = -3y^{(2)} - 3\dot{y}$

a. Which of the above differential equations are not suitable for a transfer function representation? Why?

b. Determine the transfer functions for the remaining differential equations.

Problem 3:

Consider the transfer functions you found in Problem 1.

a. Which of the transfer functions are stable?

b. Which of the transfer functions are proper?

Problem 4:

The following transfer function is given (k is real constant)

$$G(s) = \frac{s+1}{s^2 + k\,s + 4}$$

a. Is G proper?

b. For which values of k do you expect oscillations?

c. For which values of k do you expect an unbounded step response?

d. Choose k such that G becomes a first-order lag

e. Simulate a step response of $G(s)$ for different values of k