Exercise Sheet 2

Problem 5:
Consider the feedback loop with the reference signal \( r \) and the input disturbance signal \( d_i \). The controller and plant transfer functions are

\[
C(s) = K \frac{s + 4}{s + 1} \quad G(s) = \frac{1}{s}
\]

a. Is the feedback loop internally stable for \( K = 1 \) and \( K = 14 \)?

b. Which steady-state output for reference steps do you expect for \( K = 1 \) and \( K = 14 \)?

c. Which steady-state output for the response to disturbance steps do you expect for \( K = 1 \) and \( K = 14 \)?

d. Simulate the reference step response and disturbance step response for \( K = 1 \) and \( K = 14 \) and verify the results in a. to c.

e. Now compare the controllers for \( K = 1 \) and \( K = 14 \). Which controller achieves better reference tracking/disturbance rejection?

Problem 6:
We perform a speed control experiment with a DC motor.

a. Download the Simulink model of the DC motor from the course webpage. The input signal is the supply voltage \( u \) and the output signal is the rotational velocity \( \omega \). In addition, there is a disturbance signal \( T_L \) which represents a load torque.

b. Perform step responses for \( u \) (1 V) and \( M_L \) (10\(^{-3}\) Nm) and plot the result. Use the parameter values in the following table \((J_a = J_L + J_M)\).

\[
\begin{array}{|c|c|c|c|c|}
\hline
J_L & J_M & R_a & L_a & \Phi_F \\
\hline
2 \cdot 10^{-6} \text{ kg m}^2 & 1 \cdot 10^{-6} \text{ kg m}^2 & 10 \Omega & 2 \text{ mH} & 0.05 \frac{Nm}{A} \\
\hline
\end{array}
\]

Put the DC motor plant model in a feedback loop. Choose \( C(s) = 1781 \cdot \frac{8.14 \cdot 10^{-4} s + 1}{s} \).

Observe the step response to a reference step \( r = 20 \text{ rad/sec} \) and a disturbance step of \( M_L \) (10\(^{-3}\) Nm).

c. Is the feedback loop internally stable?

d. Are the closed-loop poles complex or real? Justify your answer!