EE324, Control Systems Lab, Problem sheet 3
(Report submission date: 31st January 2021)

Q1: On pole zero cancellation.
a) Consider the the transfer function (s+5+a)/(s^2+11*s+30), where ‘a’ is a real parameter to be varied from -1 to 1 in steps of 0.01. Plot the step response of the system for the various values of ‘a’. Check whether the response remains the same after pole-zero cancellation when a = 0.
Hint: Use ‘simp’.

b) Plot the step response for the system 1/(s^2-s-6). State your observations on the system. Now generate a new transfer function by adding a zero to the system to cancel the pole on the right-half of the complex plane. Plot the step response of the new system. Comment on stability (boundedness) of the response. Shift the zero slightly by adding a small variable parameter, ‘a’, and plot the response for different values of this parameter. Comment on the stability (boundedness) of these responses. From these observations try to justify the following statement: “an unstable plant cannot be rendered stable by cancelling unstable poles by adding zeros attempting to cancel the unstable pole.”

Q2: On second order approximation.
a) Plot the step response of the system 85/(s^3+7*s^2+27*s+85). Now determine a second order approximation of the system and plot the step response of the approximated system.
Hint: Find out from the textbook (or any other reliable sources) how a second order approximation is done. (Plot the two step responses in the same figure.)

b) Plot the step response of the system (s+0.01)/(s^3+(101/50)*s^2+(126/25)*s+0.1). Now determine a second order approximation of the system and plot the step response of the approximated system (in the same figure).

Q3: Effect of additional poles, zeros.
a) Consider a system 9/(s^2+2s+9). Use ‘trfmod’ to determine the poles of the system. Now add a zero to the system and determine the time domain parameters - rise time, percentage overshoot of the step responses of the original system and the one with the additional zero.

b) To the system 9/(s^2+2s+9) now add a new pole closer to the origin from the existing poles and determine the time domain parameters. Repeat the same by adding a pole away from the origin from the existing poles and determine the time domain parameters.

c) State your observations on the effect of additional poles and zeros on the system.

Q4: Plotting various time-domain parameters as functions of ζ and ω_n .
a) Consider a standard closed loop second order transfer function with undamped natural frequency of 1 rad/sec. Plot the time-domain step response of the transfer function in three cases by choosing a damping ratio such that the system is undamped, underdamped, and overdamped. Print upto three decimal places the percentage peak overshoot, peak time, delay time, rise time, 2% settling time for the three cases. Observe how percentage-overshoot, rise-time, 2% settling time, and peak-time change with change in damping ratio.
Hint: Use ‘denom’ and ‘coeff’ to get the coefficients of the characteristic equation from the transfer function.

b) Repeat the process for an underdamped system by varying the undamped natural frequency keeping the damping ratio constant. You can consider upto 5 undamped natural frequencies with increments in steps of 2. Observe how percentage-overshoot, rise-time, 2% settling time, and peak-time change with change in undamped natural frequency.