Q1. The open loop transfer function in the unity feedback configuration is given as $G(s) = \frac{K}{s(s+1)(s+2)}$.

a. Draw the Nyquist plot by selecting a suitable Nyquist contour. Comment on the stability and find out the gain margin and phase crossover frequency. [7 marks]
b. Comment on the stability when K=10 and find out the phase margin and gain crossover frequency. If the system is unstable, how many poles are RHS of s-plane using Nyquist stability criterion. [3 marks]
c. Comment on the stability when K=3 and find out the phase margin and gain crossover frequency. [5 marks]

Q2. The open loop transfer function in the unity feedback configuration is given as $G(s) = \frac{1-\frac{s}{8}}{s(s+4)}$.

a. It is required to ensure a settling time of one second with damping constant $\zeta = 0.5$. Find desired gain crossover frequency w_g and desired phase margin PM. Looking at the desired specifications and Bode plot, which compensator would you design? Design the suitable compensator that would ensure desired phase margin at the desired gain cross-over frequency. [10 marks]
b. Without computation, propose a compensator C(s) such that the gain plot C(s)G(s) is a straight-line with the slope of -20 dB/decade. [5 marks]
    - Find the gain cross-over frequency w_g at which PM = 50^{o} can be ensured for the compensated system C(s)G(s).
    - Find the gain that would ensure that the required w_g is achieved.

Q3. The open loop transfer function in the unity feedback configuration is given as $G(s) = \frac{K}{s^2(s+3)}$. It is required that the settling time of $t_s = 3$ sec, and peak overshoot M_p = 20% are satisfied for the compensated system. Design a suitable compensator using root locus. Please ensure that your design does not violate dominant pole criteria, i.e. you started with desired dominant pole pairs and your closed loop poles must not violate this condition. [15 marks]

Q4. a. $A = \begin{bmatrix} -1 & 0 \\ 0 & -2 \end{bmatrix}$, find e^{At} [2marks]

b. $A = \begin{bmatrix} -1 & 1 \\ 2 & 0 \end{bmatrix}, B = \begin{bmatrix} 1 \\ 2 \end{bmatrix}, C = [1\ 0]$. Find $\frac{Y(s)}{U(s)}$ and $y(t)$ to a unit step input. [4 marks]

c. d(s) = $s^4 - s^2 + 2s + 2$.

(i) Is the system stable or unstable without doing any further computation?

(ii) Find out how many poles in RHS plane if the system is unstable. [1+3 marks]

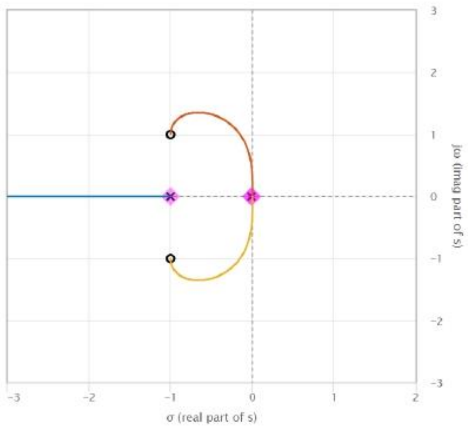
d. Given the plant $G(s) = \frac{K}{s(s+3)}$, in a unit feedback configuration. Design K such that $t_s = 1\ sec.$ [2 marks]

e. (i) Can a first order system exhibit an overshoot in its time response?

(ii) Can a combination of first order systems exhibit an overshoot in its time response? Why?

(iii) Draw the typical time response of 2nd order NMP system. [0.5+0.5+1 marks]

f. Looking at the root locus, find out the open loop transfer function. [2 marks]



g. The Asymptotic bode plot is given. Find out the transfer function. [3 marks]