Indian Institute of Technology Delhi
Department of Electrical Engineering

ELL225, Minor-II, **Control Engineering I** **2017-18/II**

Total Time: 1 hour. **Maximum marks: 21; Q1:6, Q2:4, Q3:4, Q4: 7.**

- Write clearly each step of your calculation.

Q1. Suppose G(s) is an under-damped second order system where $G(s) = \frac{2K}{(s+1)(s+2)+2K}, K > 0.$

(a) Find K such that undamped natural frequency will be 3 rad/sec? Using this K, find the **damped oscillation** frequency & the **settling time** (2% tolerance) due to a unit step input.

(b) Suppose $G_c(s)$ is a **lead** compensator where $G_c(s) = \frac{1+Ts}{1+\alpha Ts}., T > 0$ Draw the asymptotic Bode magnitude plot of $G_c(s)$?

Q2. Suppose G(s) is the open loop plant transfer function of a unity negative- feedback system where

$$G(s) = \frac{k}{s^4 + 10s^3 + 35s^2 + 50s + 10}$$

A specification on control system is that the steady state error is less than 0.05 due to a unit step input. Is it possible to achieve this specification by selecting the parameter k >0? Justify your answers with necessary calculations.

Q3. The characteristic equation of a closed loop unity-feedback system is

$$\Delta(s) = s^3 + 9s^2 + k(s+1) = 0$$

(a) Sketch the root locus of the system as k varies from 0 to ∞? Determine centroid, angle of asymptotes and breakaway points?

(b) Using magnitude criteria of the root locus, determine k at the non-zero break-away point.

Q4. Consider a unity negative feedback system with open loop transfer function $G(s) = \frac{K(s+1)}{s^2(s-2)}, K > 0$.

(a) Draw the Nyquist plot of the system in G(s) plane. Show all the intermediate computations.

(b) Verify the stability of the system using Nyquist stability criteria.

(c) The polar plot of another open-loop transfer function $G_1(s)$ of a unity negative feedback system is shown in the figure. Determine the **all possible ranges/conditions** on scalars K_1, K_2 and K_3 such that the closed loop system is stable? Give justifications. It is assumed that $G_1(s)$ has no open loop pole in the right-half of complex plane including imaginary axis

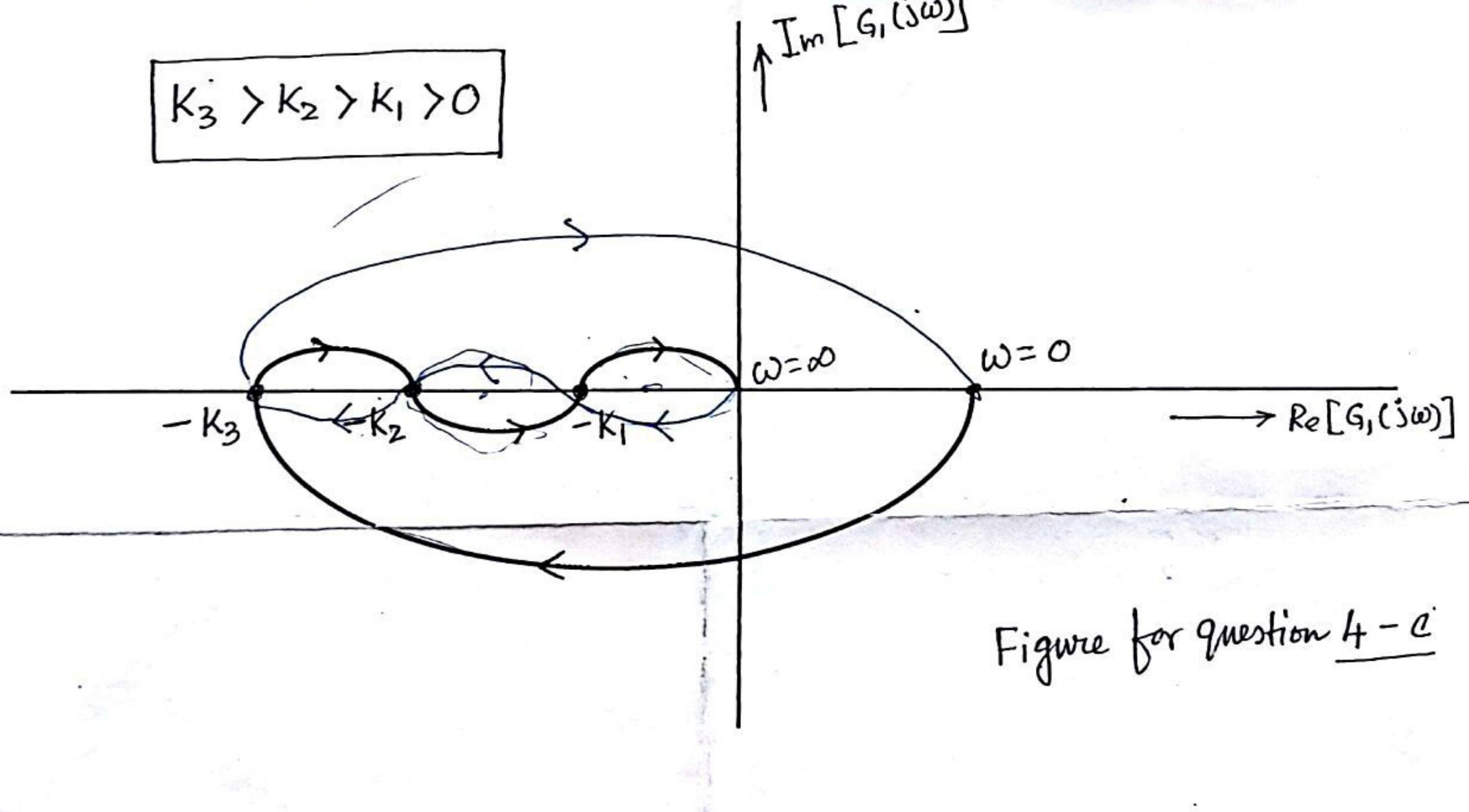

Figure for question 4 - c