Istanbul Technical University
Faculty of Electrical and Electronics
Department of Control and Automation Engineering

Feedback Control Systems
(KON313E)

Homework Assignment 3

Prepared By

1.
2.
3.
4.

2015 - 2016 Fall Term
Deadline: 31.12.2015

FEEDBACK CONTROL SYSTEMS (KON 313E)

HOMEWORK ASSIGNMENT - 3 SOLUTIONS

Question 1.a:

- Closed-loop transfer function:

Question 1.b:

- Calculation of the parameters:

Question 1.c:

- Y(s) / D(s) transfer function:

- Steady- state error:

Question 1.d:

- Rearrangement of the transfer function:

1- Poles and zeros:

2- Number of branches:

3- Symmetry:

4.1- Number of asymptotes:

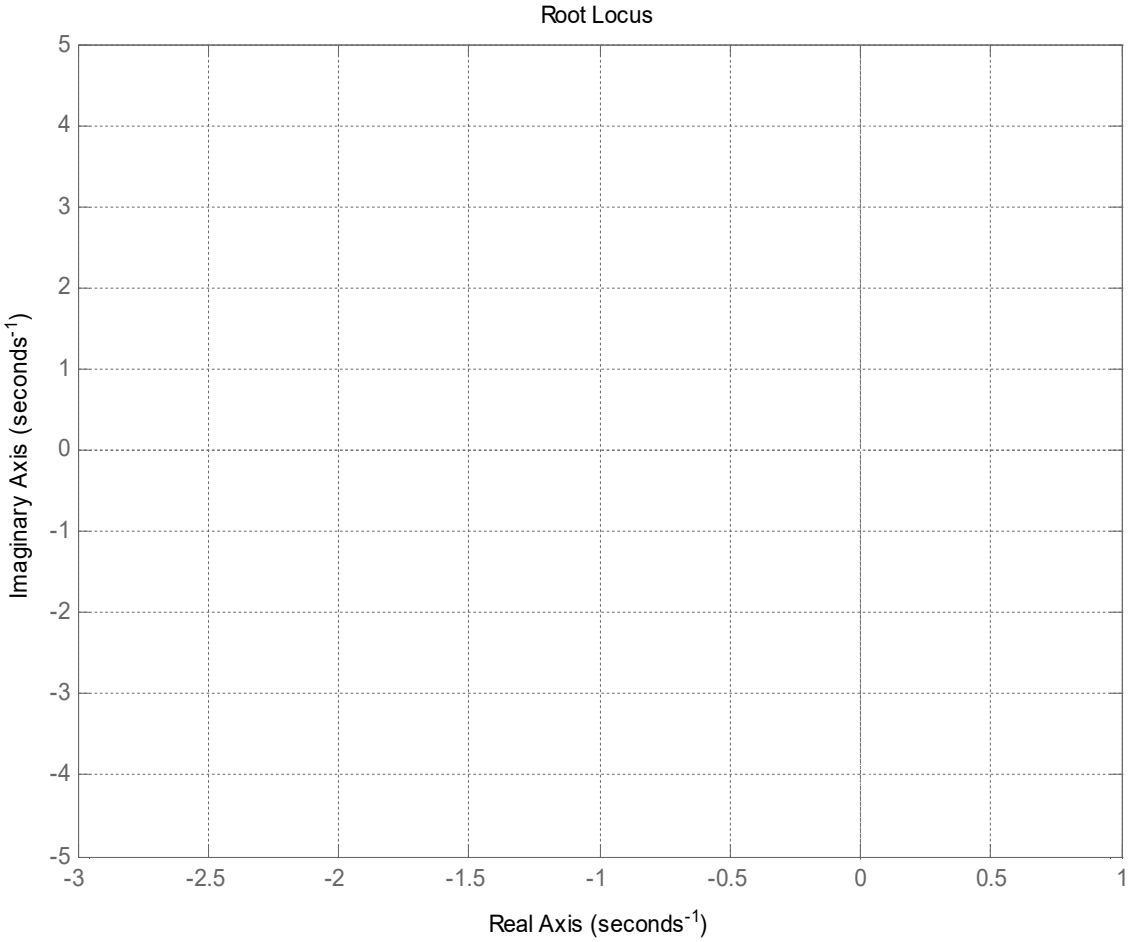
4.2- Intersection point of asymptotes:

4.3- Angle with the real axis:

5- Root-locus on the real axis: (To be shown on the drawing)

6- Calculation of the breakpoints of imaginary axis:

7- Calculation of the breaking points:



Question 2.a:

- Open-loop transfer function (parametrically):

Question 2.b:

- Amplitude and frequency of the input signal (sinus):

- Amplitude and phase shift of the system output:

- Obtaining the open-loop transfer function with the help of frequency response:

- Calculation of the values of parameters R and C:

Question 2.c:

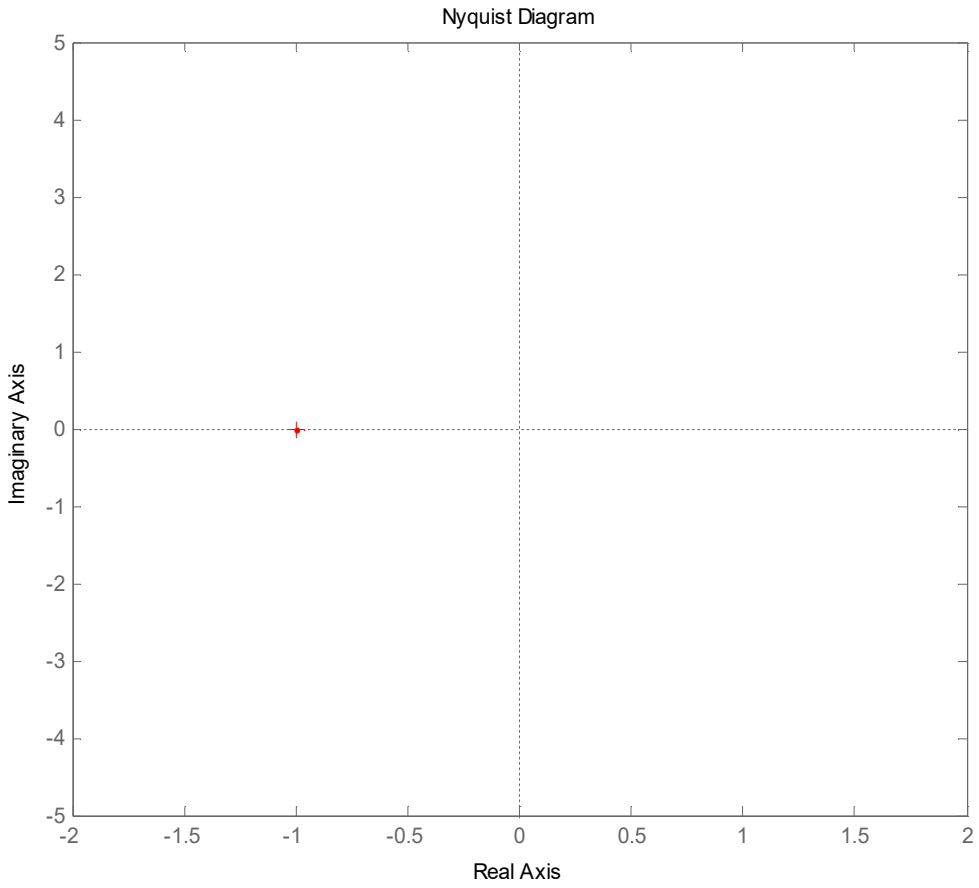
- Open-loop transfer function with F(s):

- Magnitude and phase expressions of F($j\omega$)G($j\omega$):

- Table for various ω values:

$\boldsymbol{\omega}$	$\lvert F(j\omega)G(j\omega)\rvert$	$\angle F(j\omega)G(j\omega)$
0		
10		
40.82		
60		
∞		

- Nyquist diagram and stabilizing k interval:



Question 3.a:

- Stabilizing value range of k:

s^3	
s^2	
s^1	
s^0	

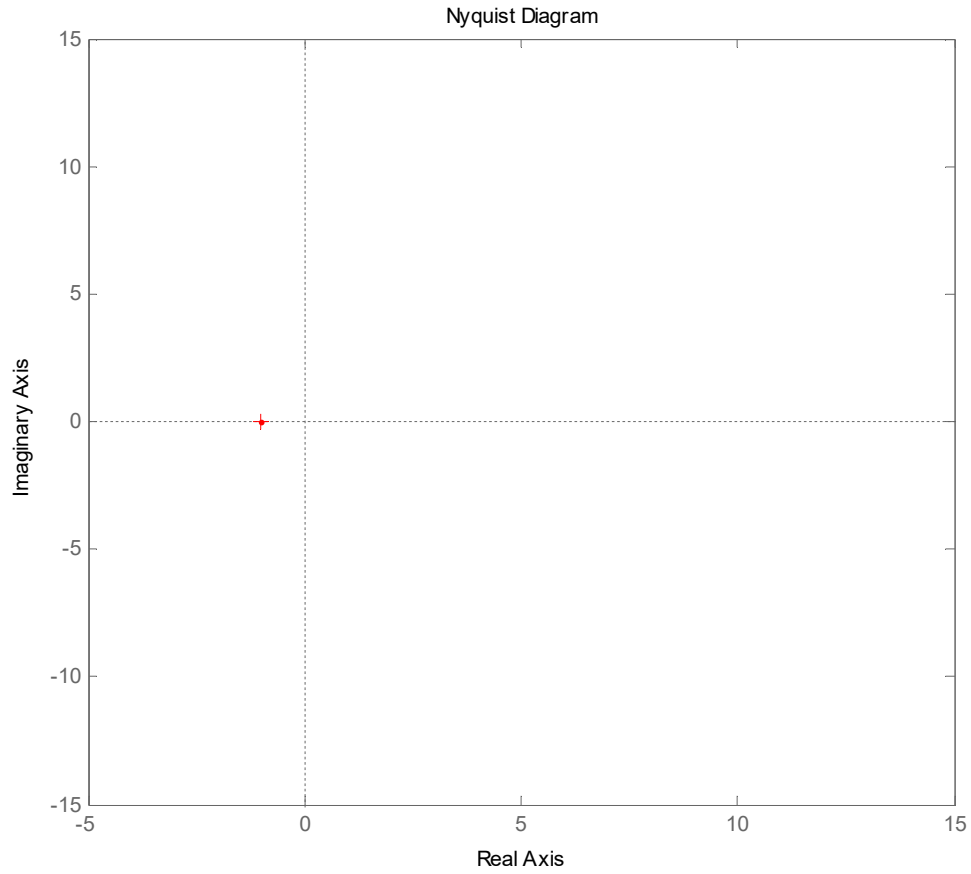
Question 3.b:

- Magnitude and phase expressions of G($j\omega$):

- Table for various ω values:

$\boldsymbol{\omega}$	$\lvert G(j\omega)\rvert$	$\angle G(j\omega)$
0		
0.2		
0.7071		
10		
∞		

- Nyquist diagram:



- Stabilizing k interval:

Question 3.c:

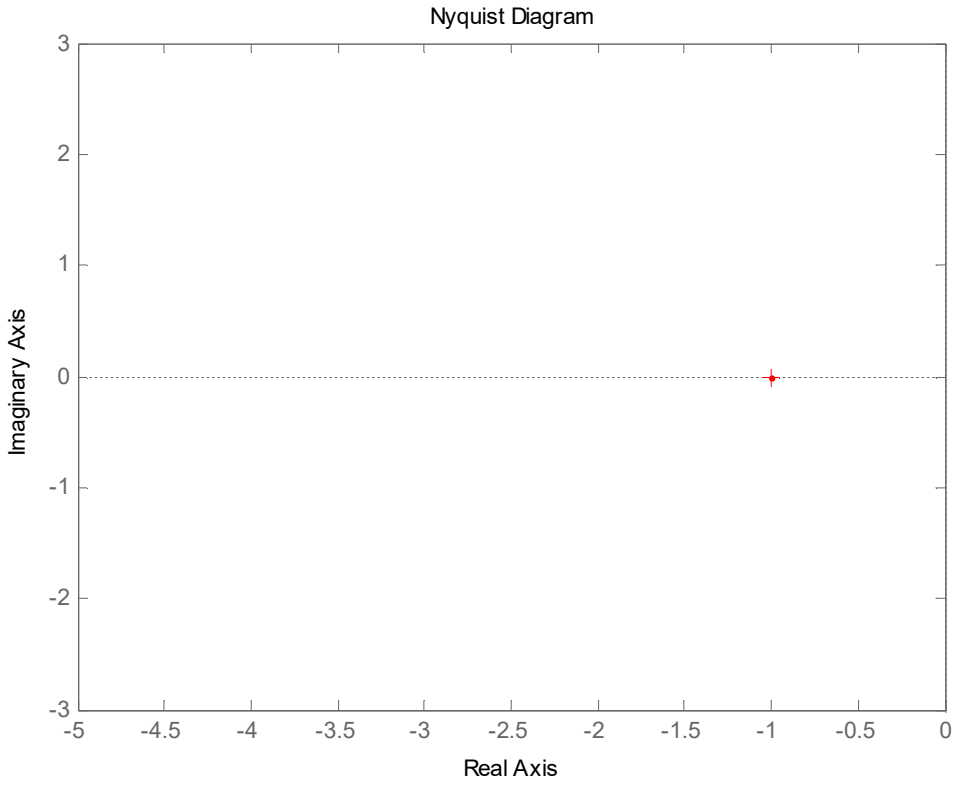
- Rough drawing of the new Nyquist path:

- Modified magnitude and phase expressions:

- Table for various ω values:

$\boldsymbol{\omega}$	$\lvert G(j\omega)\rvert$	$\angle G(j\omega)$
0		
0.5		
1.3638		
5		
∞		

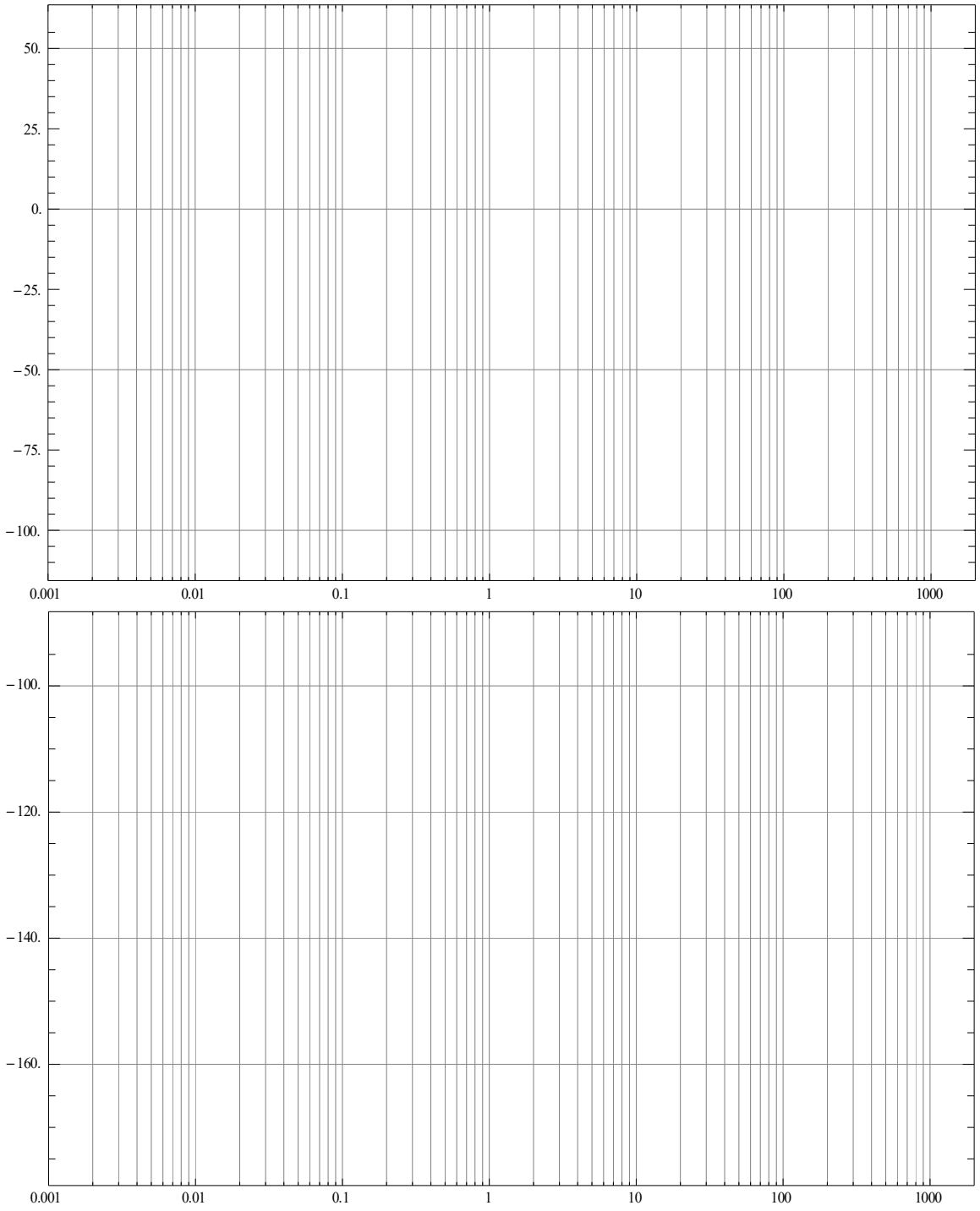
- Nyquist diagram and value range of the parameter k:



Question 3.d:

- Rearrangement of the open-loop transfer function:

- Bode magnitude and phase plots:



- Phase and gain margins:

- Stability of the system:

Question 3.e:

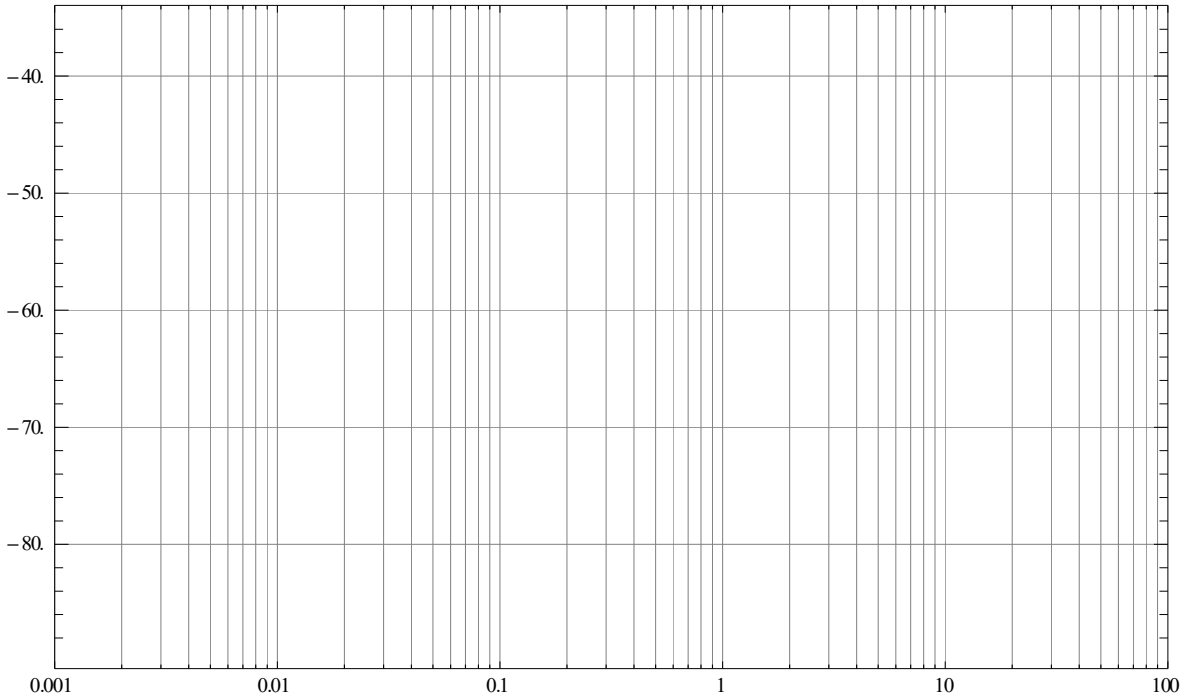
- Expression of the system output:

Question 4.a:

- Open-loop transfer function:

Question 4.b:

- Phase diagram:



- Calculation of the phase and gain margins:

Question 4.c:

- Calculation of the critical L value: