Last name **Name** **student ID No.:**

Section 4: STABILITY OF LINEAR DYNAMIC SYSTEMS

A closed-loop dynamic system is made of P controller

$$G_c = K_c$$

a purely algebraic final control element with $G_f = 1$,
a process G_p having the following transfer function

$$G_p = \frac{\frac{1}{n}}{\left(s^2 + n^2\right)^2}$$

a measuring device with

$$G_m = \frac{1}{(s+n)}$$

where n = PC No.

I. What is the **open-loop feedback transfer function**?
II. What is the open-loop system **order**?
III. Is the open-loop system an **integrator** process?
IV. Is the open-loop system a **minimum phase system**?
V. How much is the open-loop system **gain**?
VI. How many and how much are the **time constants**?
VII. Is there any **damping factor**? If there is, how much is ζ ?

Part A: *Root locus*

For the open-loop dynamic system plot the *root locus* by means of Matlab and SisoTool resources, attach it here and answer the following questions:

a) Determine poles, zeroes and No. of trajectories.
b) Do you use **direct or inverse root locus** rules? Why?
c) Determine parts of *root locus* coincident with the real axis.
d) Discuss existence of asymptotes and, if possible, calculate the gravity center and angles formed with the real axis.
e) Discuss and, if possible, calculate starting and ending angles for poles and zeroes.
f) Discuss and, if possible, calculate the *breakaway points*
g) Discuss the BIBO stability of the system when K_c is changed
h) Calculate the limiting value/values for K_c, if any

i) In the present case, is a switch from a P controller to a PD controller more favorable in view of closed-loop feedback stability? Why?

Part B: Frequency response

For the open-loop dynamic system with $K_c=1$:

1) Plot the Bode Diagrams by means of Matlab/Sisotool resources and attach them here
2) Plot the asymptotic Bode Diagrams by means of ASBODE script and attach them here
3) Discuss the asymptotic behavior for low and high frequencies.
4) Calculate **AR** for ω = 20 rad/s
5) Does a **resonance** frequency exist? How much is it?
6) Does a *crossover* frequency exist? How much is it?
7) Does a *gain crossover* frequency exist? How much is it?
8) Check, on the base of the Bode stability criterion, if the above system is closed-loop stable
9) Plot the **Nyquist** Diagram by means of Matlab/Sisotool resources and attach it here
10) Check, on the base of the **Nyquist** stability criterion, if the above system is closed-loop stable
11) Calculate the **gain margin** and the **phase margin**, if any
12) What is the definition of **ultimate gain** K_u?
13) Calculate the **ultimate gain** K_u, if possible

Part C: Dynamic responses in the time domain

For the open-loop dynamic system with $K_c=1$:

1) Plot the **open-loop** and **closed-loop** system dynamic responses to a unit step change in *set point* by means of Matlab resources, attach them here and give your comments.
2) Plot the **closed-loop** system dynamic responses to a unit step change in *disturbance du* by means of Matlab resources, attach them here and give your comments.