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

PC No. ___________

Section 4: STABILITY OF LINEAR DYNAMIC SYSTEMS

A dynamic process G_p is the result of 2 linear systems in series, each having the following transfer function

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

$$G_{dt} = e^{-\frac{n}{2}s}$$

where:

n = N. matricola (student ID No.)

I. Is $G_p(s)$ a BIBO stable system at **open-loop**?

II. How much is the **type "g"**?

III. Is $G_p(s)$ a **minimum phase system**?

IV. How much is the **gain**?

V. How many and how much are the **time constants**?

VI. Is there any damping factor? If there is, how much is ζ ?

Part A: *Root locus*

A1. For the **dead time** $G_{dt}(s)$, determine the 3rd order **Padè approximation** and report it here

A2.Determine the new fully rational transfer function that you obtain for the process, $G_{p,approx}(s)$, after replacing the **dead time** with the **Padè approximation**

A3.Plot the root locus by means of Matlab and SisoTool resources and attach it here

A4.Calculate, if any, the **breakaway points** and discuss them

A5.Calculate, if any, the limiting value/values K^* and discuss them

Part B: Frequency response

For the open loop **original dynamic system** $G_p(s)= G_{raz}(s)\ G_{dt}(s)$ reported on top and ***Kc=1***, answer the following questions:

B1) Plot the **Bode Diagrams** by means of Matlab/SisoTool resources, with a *log scale of the magnitude (NOT in dB)*, and attach them here

B2) Does a **resonance** frequency exist? How much is it?

B3)Does a *crossover* frequency exist? How much is it?

B4)Does a *gain crossover* frequency exist? How much is it?

B5)Decide if the **Bode stability criterion** is applicable

B6) If yes, is the above system closed-loop stable?

B7)Calculate the **phase margin**

B8)Determine from the **Bode Diagrams** the limiting value K^* and compare it with the previous value found under the **Padè approximation**

B9)Calculate the value of TF $G_p(s)$ in **polar coordinates** (AR, ϕ) at a given $\omega = 5$ rad/s

B10) Calculate the value of TF $G_p(s)$ in **cartesian coordinates** as a **complex number** (a + jb) at a given $\omega = 2$ rad/s

Part C: Dynamic responses in the time domain

With ref. to the open loop **original dynamic system** $G_p(s)= G_{raz}(s)\ G_{dt}(s)$ reported on top, answer the following questions:

C1. Plot the **open-loop** dynamic response to **unit step**, attach it here and give your comments

C2. Determine the time at which the value of **open-loop** dynamic response becomes equal to 90% of its ultimate value

Part D:

D1) Write the **transfer function** of the Dead time compensator and give your comments