Numerical Methods for Dynamic System and Control

Course project

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1 Introduction

The project consists in carrying out the tasks given and record all the results in a **short** written report (max 6 pages), ideally using LaTeX (or LyX). Attention should be paid to:

1. Correctness of the results.
2. Presentation of the results and layout of the report.
3. Critical discussion of the results using the studied theory and course materials.

The contents of the report will then be discussed (orally) with the examiners, at which the student may be asked to explain details of the programs and to re-run some of the problems. The project is *individual* and score in the range $[-3, 3]$ is added to the final mark. The project should be handed in electronic form (zip archive file) to the lecturers, calling the file: `surname_name_NMDSC2011_project.zip`. The archive must contain the project report (in pdf) and the related programs written in MATLAB/MAPLE. Other accepted programming languages are SCILAB, Octave, FORTRAN, C, C++ and BASIC.

2 The project

Consider one of the DAE in equation (1) the specific DAE will be assigned in the following way. Take the first two letter of name and surname, for example if you are Bartolomeo Pestalozzi the letters are BAPE. Given the letters get the number from the corresponding column on the following table,

$A = 1$	$B = 2$	$C = 3$	$D = 4$	$E = 5$	$F = 6$
$G = 7$	$H = 8$	$I = 9$	$J = 10$	$K = 11$	$L = 12$
$M = 13$	$N = 14$	$O = 15$	$P = 16$	$Q = 17$	$R = 18$
$S = 19$	$T = 20$	$U = 21$	$V = 22$	$W = 23$	$X = 24$
$Y = 25$	$Z = 26$				

in this case 2, 1, 16 and 5. Then compute

$$\Big(n_1 + 3\,n_2 + 7\,n_3 + 13\,n_4 \mod 5\Big) + 1$$

which is the number of the assigned exercise. For example for Bartolomeo Pestalozzi we have

$$\Big(2 + 3 \cdot 1 + 7 \cdot 16 + 13 \cdot 5 \mod 5\Big) + 1$$

$$\Big(182 \mod 5\Big) + 1$$

$$2 + 1 = 3$$

and the exercise is the number 3. For the assigned DAE do the following task:

- Compute the differential index of the DAE.
- Write and implement implicit Euler or Taylor numerical scheme with Baumgarte stabilization.
- In alternative, only for the brave, write and implement coordinate partitioning numerical scheme with Runge-Kutta or other explicit numerical scheme.
- Estimate numerically the order of convergence for the implemented scheme.
- Plot and comment all the numerical solutions.

Assigned DAE's Find the solution $x(t)$, $y(t)$, $\mu(t)$ of:

$$\text{Prob. 1} \qquad \begin{cases} x'' = \mu\, x \\ y'' = \mu\, y + 3\cos(t)^2 \\ y = x^2 + 1 \end{cases}$$

$$\text{Prob. 2} \qquad \begin{cases} x'' = \mu\, y \\ y'' = \mu\, x + e^t - e^{-3\,t} \\ x\, y = 1 \end{cases}$$

$$\text{Prob. 3} \qquad \begin{cases} x'' = \mu - x \\ y'' = \mu + y - 5\cos(t)^2 + 2 \\ y = x^2 \end{cases} \tag{1}$$

$$\text{Prob. 4} \qquad \begin{cases} x'' = \mu\, x \\ y'' = \mu - y - 3\cos(t)^2 + 2 \\ y = x^2 - 1 \end{cases}$$

$$\text{Prob. 5} \qquad \begin{cases} x'' = \mu\, x + t^2 - 3 \\ y'' = \mu\, x + y \\ y = x^2 - 1 \end{cases}$$

initial data $x(0)$, $y(0)$, $\mu(0)$, $x'(0)$, $y'(0)$ must be chosen that satisfy the constraint.