Obuda University John von Neumann Faculty of Informatics	Institute of Applied Mathematics

Name and code: *Sytem and Control Theory (NIXRI1PMNE)* **Credits*: 6***

Applied Mathematics MSc Daytime (Special) Course, Academic Year: 2021/22, Semester: I.

Subject lecturer(s): Prof. Dr. József Kázmér Tar József

Prerequisites (with code):	Differential Equations (NMXDE1PMEE)[1]

Weekly hours:	Lecture: 2	Seminar.:0	Lab. hours: 2	Consultation: 0

Way of assessment:	Oral examination

Course description

Goal:: Providing the Students with with the fundamental classical knowledge in control technology. Following that considering certain modern approaches.

Course description: Model Predictive Controller (MPC): optimization under constraints, Lagrange multipliers, reduced gradient, auxiliary function, nonlinear programming. The heuristic Receding Horizon Control. Simulation issues: MS EXCEL – Solver, legally free alternatives of MATLAB: Julia Version 1.0.3 (2018-12-18). General description of the LTI systems: stability, observability, controllability. The method of “Pole Placement”. State estimation by the Luenberger Observer. MPC for LTI models and quadratic cost functions: the LQR regulator. Tackling the LTI systems in the frequency domain: basics in Distribution Theory: the function class $\mathscr{D}$ and its use for classical modelling. Singular Value Decomposition (SVD), the H_\infty nomr, robust design, the “minimax” principle. Robust nonlinear controller: the Sliding Mode / Variable Structure Controller. Adaptive controllers: the “kappa” function class, Lyapunov’s “stability”, “uniform stability”, and “asymptotic stability” definitions, quadratic Lyapunov functions, the “Adaptive Inverse Dynamics Robot Controller”.

Lecture schedule

[1] 2021. September 05.

Education week t (consultation)	Topic(s)
1.	General theory of model based controllers: the Model Predictive Controller (MPC) as a special Optimal Controller.
2.	Optimization under constraints: Lagrange multipliers, Reduced Gradient, Auxiliary Function, Nonlinear Programming.
3.	The heuristic Receding Horizon Controller: Cost functions and their qualitative features.
4.	Numerical simulation issues: MS ECEL SOLVER-VBA, the MATLAB and its free alternatives: Julia Version 1.0.3 (2018-12-18).
5	Application example for an RHC controller.
6.	The Canonical Form of the Linear Time-Invariant (LTI) models. The general solution. Similarity transformations, generalized eigenvectors, Jordan chains, Jordan’s canonical form, nilpotent matrices, Cayley-Hamilton theorem, stability, controllability, observability.
7.	The method of Pole Placement.
8.	State estimation: the Luenberger Observer for LTI systems.
9.	The LQR regulator. Riccati equations.
10.	Tackling the LTI systems in the frequency domain: the Laplace Transform and the Transfer Function. Basics of Distribution Theory: the function class $\mathscr{D}$ and its use for classical modelling, the behaviour of the Laplace Transform of these functions.
11.	The Singular Value Decomposition for complex matrices. The greatest singular value as a norm. Robust design for LTI systems to compensate the effects of external disturbances. The H_\inty norm, the “minimax” principle in the design.
12.	The Robust VS/SM Controller for Nonlinear Systems to compensate the effects of modelling errors and external disturbances.
13.	Adaptive Controllers.
14.	Consultation before the examination.

Midterm requirements

In this subject area making written tests does not have educational value. Solving a particular control task, and making its documentation can be evaluated.

2021. September 05.

Written tests	
Week (consultation)	Subject area
1	Not relevant.
2	Not relevant.
3	Not relevant.

Final grade calculation methods

Solving a particular control task, making its documentation, and submmitting these materials.

Type of replacement

Examination for obtaining the „signature”.

Type of exam

Classic oral examination (colloquium).

Vizsgajegy kialakítása

In discussion with the Student.

References

Mandatory:

Recommended:

1. Lantos Béla: Irányítási rendszerek elmélete és tervezése II., Akadémiai Kiadó, 2003
   2. Bokor József, Gáspár Péter: Irányítástechnika járműdinamikai alkalmazásokkal, Typotex Kiadó, 2008
2. Kemin Zhou, John C. Doyle, Keith Glover: Robust and Optimal Control, Pearson; 1 edition, 1995.
3. 3. J. K. Tar, L. Nádai, I. J. Rudas: System and Control Theory with Especial Emphasis on Nonlinear Systems, TYPOTEX, Budapest, 2012, ISBN 978-963-279-676-5

Other aids:

2021. September 05.

Lecture notes in PDF and sample programs are available for the Students.

2021. September 05.