M130	**Control Theory**	L	P	S	ECTS
		3	2	1	8

Course objectives. Introduce students to matrix theory and numerical methods that are used in a control of linear systems and in an optimal control. Model and solve real life problems that can be formulated in terms of control theory. Study basic methods for calculating matrix functions and solving matrix equations that arise in control theory. Investigate and implement solutions of problems in control theory that arise in applications. On examples apply numerical methods for efficient calculation of optimal control. Use programming packages for implementation of studied methods and for testing of methods in different real-life examples.

Prerequisites. Undergraduate study programme in mathematics or computer science. Applied linear algebra and scientific computing.

Course content.

1. Introduction. Motivation and basic concepts, state-space representation, matrix functions.
2. Transfer function. Controllability and observability.
3. Eigenvalue assignment.
4. Lyapunov and Riccati equation and methods for their solution. Stability and inertia.
5. Model realization and subspace identification.
6. Feedback stabilization and eigenvalue assignment.
7. H2 and H∞ optimal control.
8. Numerical methods for optimal control and their application to real life examples.

LEARNING OUTCOMES

No.	LEARNING OUTCOMES
1.	Define controllability and observability concepts.
2.	Apply methods for solution of matrix equations.
3.	Recognize problems from control theory in different areas.
4.	Explain stability concepts.
5.	Apply methods for optimal control.
6.	Formulate example of optimal control and apply studied methods with appropriate interpretation of results.
7.	Describe possibilities of applications in control based on different criteria.
8.	Implement and illustrate studied methods using programing tools.
9.	Apply methods for feedback stabilization and eigenvalue assignment.

RELATING THE LEARNING OUTCOMES, ORGANIZATION OF THE EDUCATIONAL PROCESS AND ASSESSMENT OF THE LEARNING OUTCOMES

TEACHING ACTIVITY	ECTS	LEARNING OUTCOME **	STUDENT ACTIVITY*	EVALUATION METHOD	POINTS	
					min	max
Attending lectures and exercises	1	1-9	Lecture attendance, discussion, team work and independent work on given tasks and short exams	Attendance lists, tracking activities exams	0	4

Seminar assignment	1	1-9	Independent work on exercise	Seminar evaluation	5	14
Written exam (Mid-terms)	3	1-9	Preparing for written exam	Evaluation	20	36
Final exam	3	1-9	Revision	Oral exam	25	46
TOTAL	8				50	100

Teaching methods and student assessment. Lectures and seminars are obligatory. Exam is held after completion of lectures and it includes a written and an oral part. Students can take mid-term exams during the semester. Acceptable mid-term exam scores replace the written examination. Exercises are partially done using mathematical software on computers. Seminar assignment also influences the final grade. Seminar assignments need to be done during semester. In this seminar assignment students need to implement studied methods and interpret obtained results.

Can the course be taught in English: Yes

Basic literature:

1. B.N. Datta, Numerical Methods for Linear Control Systems, Academic Press, 2003.
2. K. Zhou, J. C. Doyle, K. Glover, J. C. Doyle, Robust and optimal control, Prentice Hall, 1995.

Recommended literature:

1. J.W. Demmel, Applied Numerical Algebra, SIAM, 1997.
2. K. Zhou, J. C. Doyle, Essentials of robust control, Prentice Hall, 1997.
3. C. T. Kelley, Iterative methods for optimization, SIAM, Philadelphia, 1999.
4. A. C. Antoulas, Approximation of Large-Scale Dynamical Systems, SIAM, Philadelphia, 2005.
5. G. E. Dullerud, F. Paganini, A Course in Robust Control Theory, Springer Verlag, 2000.
6. F.L. Lewis, V.S. Syrmos, Optimal control, Wiley, Hoboken, 2012 .