M132	**Model reduction and approximation methods**	L	P	S	ECTS
		2	1	1	6

Course objectives. Introduce students to model reduction and approximation methods for numerical determination of reduced model. Study basic methods for model reduction and solution of large-scale matrix equations. Investigate and interpret problems for model reduction that arise in applications. Implement numerical methods for model reduction on examples. Use programing 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 from linear system theory.
2. Methods that are based on eigenvalues: balanced truncation, dominant pole algorithm.
3. Approaches based on balancing.
4. Numerical methods for solution of large-scale matrix equations: ADI method, sign function method.
5. Interpolatory methods for reduction: moment matching, H2 optimal reduction.
6. Methods for parametric model reduction.

LEARNING OUTCOMES

No.	LEARNING OUTCOMES
1.	Define concepts of balancing and dominant poles.
2.	Apply methods for solution of large-scale matrix equations.
3.	Recognize problems from large-scale systems in different areas.
4.	Explain concepts important for model reduction.
5.	Apply methods for model reduction.
6.	Formulate example of linear system and apply method for reduction with appropriate interpretation of results.
7.	Apply method for parametric model reduction.
8.	Apply programing tools in order to implement studied methods and illustration of methods on examples.
9.	Describe possibilities and applications for model reduction.

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)	2	1-9	Preparing for written exam	Evaluation	20	36
Final exam	2	1-9	Revision	Oral exam	25	46
TOTAL	6				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 as well as the seminar assignment. 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. In seminar assignment students need to implement studied methods and interpret obtained results.

Can the course be taught in English: Yes

Basic literature:

1. A. C. Antoulas, Approximation of Large-Scale Dynamical Systems, SIAM, Philadelphia, 2005.
2. W. H. Schilders, H. A. Vorst, J. Rommes, Model Order Reduction: Theory, Research Aspects and Applications, Springer, 2008.

Recommended 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.
3. K. Zhou, J. C. Doyle, Essentials of robust control, Prentice Hall, 1997.
4. G. E. Dullerud, F. Paganini, A Course in Robust Control Theory, Springer Verlag, 2000.
5. F.L. Lewis, V.S. Syrmos, Optimal control, Wiley, Hoboken, 2012.