Course program

Course code	ISS0031
Subject title	Modeling and Identification
Subject title (in estonian)	Modelleerimine ja Identifitseerimine
Lecturer	Juri Belikov
Course volume ECP	5
Stationary study (weekly hours)	lectures: 2, exercises: 2
Prerequisite subject	YMA3710 – Lineaaralgebra; ISS0021 – Automatic Control Systems
Assessment form	examination
Teaching semester	autumn

Course aims

- to show connections between mathematics, economics and control theory with respect to optimization theory;
- to give an overview of the basic modeling and optimization problems, and methods for their solution;
- to develop the ability to think systematically, formulate and analyze problems.

Learning outcomes of the subject

- knows and understands the basics of mathematical programming and control theory;
- knows the basic modelling and optimization problems;
- can formulate linear programming problems;
- can apply different methods to solve linear programming problems;
- can describe systems by using mathematical models (state-space models, input-output models, etc.);
- knows how to derive mathematical models;
- can use MATLAB environment to analyze and solve different mathematical programming and control problems.

Brief description of course content

The course will cover the following topics:
Classification of systems. Mathematical modeling of systems: analytical modeling versus identification from measured data. Operational analysis and constrained optimization problems. Linear programming: feasible region, Simplex method, Dual Simplex method. Transportation problem. Introduction to the Game theory. Linear

continuous- and discrete-time analytical models: transfer and state-space models. Obtaining mathematical models from principal schemes of mechanical, electrical, hydraulic and thermal systems. Identification of a linear model: least squares method, neural networks.

Course content and schedule

Week		Theme
#	Period	
1	02-08.09	Introduction to mathematical programming. Problem statement. Linear programming problem. Basic notions: objective function, constraints, feasible solutions
2	09-15.09	Linear programming problem: a geometric approach. Unique solution
3	16-22.09	Convex set and function. Convex optimization problem. Linear programming problem as a case of convex planning problem
4	23-29.09	Simplex method. Slack and surplus variables. Minimization and maximization
5	**30.09-06.10**	**First test**
6	07-13.10	Dual and primal linear programming problems. Duality theorems. Dual Simplex method
7	14-20.10	The transportation problem. Solvability. Basic theorems
8	21-27.10	Solution of the transportation problem: North-West corner rule, Lowest cost entry method
9	28.10-03.11	Introduction to game theory. Game as a linear programming problem
10	**04-10.11**	**Second test**
11	11-17.11	Introduction to control theory. Basic notions: state-space and input-output system, transfer function, controllability, observability, stability
12	18-24.11	Modeling: system identification
13	25.11-01.12	Modeling: neural networks
14	02-08.12	Optimal control: linear quadratic regulator
15	**09-15.12**	**Third test**
16	**16-22.12**	**Examination (first attempt)**

Independent work

Students have to be able to apply concepts and demonstrate understanding. During semester three tests and three homeworks have to be solved. Students have to be able to work with additional literature.

Evaluation criteria

The final grade consists of two parts: 60% work during the semester ($3 \times 15\%$ tests $+ 3 \times 5\%$ homework) and 40% exam.

Study literature

The material presented in lectures is partly based on the following literature:

1. Ü. Kaasik, L. Kivistik, Operatsioonianalüüs, Valgus, Tallinn, Eesti, 1982.
2. Ü. Kaasik, Matemaatiline planeerimine, Valgus, Tallinn, Eesti, 1967.
3. E. Übi, Planeerimise ja juhtimise matemaatika, Külim, Tallinn, Eesti, 1998.
4. E. Übi, Ekstreemumülesanded majanduses ja tehnikas, Külim, Tallinn, Eesti, 2002.
5. H. Sillamaa, Süsteemiteooria, TTÜ, Tallinn, Eesti, 1999.
6. T.S. Ferguson, Linear Programming: A concise introduction, e-version is available at `http://www.math.ucla.edu/~tom/LP.pdf`, 2012.
7. E. Rasmusen, Games and Information: An Introduction to Game Theory, Wiley-Blackwell; 4th edition, 2006.
8. K. Ogata, Modern Control Engineering, 5th edition, Prentice Hall, 2009.
9. Ю.И. Клименко, Высшая математика для экономистов теория, примеры, задачи, Издательство "Экзамен", Москва, 2005.