RTU Course "Analysis and Optimization of Machines, Structures and Technological Processes"

15325 Teorēt.mehānikas un materiālu pretestības katedra

General data

Code	MTM516
Course title	Analysis and Optimization of Machines, Structures and Technological Processes
Course status in the programme	Compulsory/Courses of Limited Choice; Courses of Free Choice
Course level	Post-graduate Studies
Course type	Academic
Field of study	Mechanics, Mechanical Engineering, Machine Building
Responsible instructor	Auziņš Jānis
Volume of the course: parts and credits points	1 part, 3.0 Credit Points, 4.5 ECTS credits
Language of instruction	LV, EN, RU
Possibility of distance learning	Not planned
Maximum auditorium capacity	25
Maximum number of students per semester	50
Abstract	Strategy of experiment organization. Basic statistical concepts. Classical experimental designs (Factorial design, Box-Behnken, D-optimal). Space filling designs. V.Eglajs experimental design. Latin Hypercube Design. Regression analysis. Parametric and non-parametric approximation methods. Radial basis functions. Response surface methodology. Experimental Designs for fitting of Response surfaces. Filtration of Outliers. Classification of optimization problems. Handling of nonlinear constraints. Deterministic and stochastic global optimization methods (Taboo search, simulated annealing, genetic algorithms, multistart methods). Virtual prototyping of mechanical systems. Metamodelling and optimization by using EDAOpt, ANSYS and ADAMS programs.
Goals and objectives of the course in terms of competences and skills	1. Understand the principles and mathematical basis of analysis and optimization of complex machines, structures and technological processes. 2. Learn the methodology of parametric and nonparametric metamodeling. 3. Learn, how to use global optimization software for machine, technology and structural optimization. 4. Learn, how to formulate and solve typical engineering optimization problems: performance, durability, stability, mass, cost and other. Understand the complexity and labor intensiveness of different optimization problems.
Structure and tasks of independent studies	Within the framework of the present study course the students should carry out the independent work on the following topics: Coursework 1. Analytical formulation of practical machine cost and performance optimization problems and their solution applying MathCad software. Coursework 2. Metamodel building and optimization of machine dynamics using software MSC ADAMS, WorkingModel, EDAOpt, DesignExpert. Practical works: 1. The optimization of practical tasks of mechanical system reliability, cost improvements, including criteria and constraint formulation and use of universal software. 2. Optimization of mechanical system with oscillation frequency limitation. 3. Structure cost minimization, in consideration of frequency limitation.
Recommended literature	J. Auziņs, A. Januševskis (2007). Eksperimentu plānošana un analīze, ISBN:,Rīga, RTU, 2007. Myers R. H.; Montgomery D. C. (2002). Response Surface Methodology: Process and Product Optimization Using Design Experiments. Wiley, ISBN: 0471412554, New York A. Ravindran, K. M. Ragsdell, and G. V. Reklaitis "Engineering Optimization: Methods and Applications", Wiley, 2006. M. A. Bhatti "Practical Optimization Methods: With Mathematica Applications", Springer, 2000.
Course prerequisites	Students must have knowledge of physics, higher mathematics, informatics.

Course outline

Theme	Hours
The statement and classification of practical engineering optimization tasks: objective functions and constraints.	3
Classical optimization methods: analytical and numerical gradient methods. Optimization with MathCad.	3
Optimization and experimentation. Physical and numerical experiments.	3
Statistical basics of experimental optimization: analysis of variation.	3
Statistical basics of experimental optimization: regression analysis.	3
Classical factorial designs for physical experiments.	3
Response surface methodology of optimization. D-optimal and Central composite designs.	3
Response surface method for numerical experiments. Space filling designs.	3
Parametric and nonparametric approximation methods.	3
Locally weighted polynomial approximations and kriging.	3
Methdology of metamodeling. Application for optimization of machines and structures.	3
Virtual prototyping of mechanical systems.	3
Metamodel building with softwsre EDAOpt, DesignExpert, ANSYS, ADAMS.	3
Methods of global optimization: multistart, simulated annealing.	3

Parametrical identification of mechanical systems using optimization methods.	3
Basics of sensitivity analysis, post-optimization analysis.	3

Learning outcomes and assessment

Learning outcomes	Assessment methods
Students will be competent in different optimization problem statements.	Exam tasks
Students will be able to apply analytical methods of optimization to the simplest tasks.	Questions in the practical works.
Students will be guided in the offer of widely available optimization software.	Questions in the practical works.
Students will be able to formulate and solve nonlinear optimization tasks of medium complexity, using the commercial software packages.	Course work 1.
Students will be competent in the use of physical and numerical experiments for practical optimization tasks.	Appropriate questions in the practical works.
Students will be able to use the metamodeling and response surface methodology for solving of practical optimization problems.	Course work 1.
Students will be able to evaluate the complexities and difficulties of different optimization task statement and solution. - Exam questions.	Exam

Study subject structure

Part	CP	ECTS	Hours per Week			Tests			Tests (free choice)		
			Lectures	Practical	Lab.	Test	Exam	Work	Test	Exam	Work
1.	3.0	4.5	1.0	1.0	1.0		*				