RTU Course "Optimization Methods"

15325 Teorēt.mehānikas un materiālu pretestības katedra

General data

Code	MTM408
Course title	Optimization Methods
Course status in the programme	Compulsory/Courses of Limited Choice
Course level	Post-graduate Studies
Course type	Academic
Field of study	Mechanics, Mechanical Engineering, Machine Building
Responsible instructor	Vība Jānis
Academic staff	Auziņš Jānis
Volume of the course: parts and credits points	1 part, 4.0 Credit Points, 6.0 ECTS credits
Language of instruction	LV, RU
Possibility of distance learning	Not planned
Maximum auditorium capacity	25
Maximum number of students per semester	50
Abstract	Extremes of analytic function. Extreme types. Minimum and maximum conditions of analytical function. General optimization problem formulation. Criteria and constraint types. Linear and nonlinear programming, the numerical methods. Gradient method. Local and global optimum. Universal and specialized optimization software. Functionals, the classical methods of functional minimization. Optimal control task standard form. Introduction to optimal control - Pontryagin maximum principle and dynamic programming. Introduction to multiobjective and robust optimization. In this course, students are not creating own optimization software codes, but will use specialized commercial software. Theoretical training target is to create the ability to formulate different optimization problems and use of commercial computer software for problem solution.
Goals and objectives of the course in terms of competences and skills	To provide students with relevant information on the optimization task formulation and solving methods the following task should be fulfilled: identification of objective and constraints, the use of commercial software. The typical mechanical engineering optimization tasks are: machinery and mechanical statics and dynamics and control optimization. To achieve this aim, the following tasks are fulfilled: 1. The use of analytical methods for extreme search. 2. An overview of numerical optimization methods and their implementation in commercial software. 3. Many practical optimization problems of mechanics are solved during implementation of the training tasks: speed, strength, weight, cost, etc. optimization. 4. To understanding the complexity of optimization
Structure and tasks of independent studies	Within the framework of the course students should carry out the independent work on the following topics: 1. Practical work 1. An analytical minimization of one-and two-argument functions without constraints. 2. Practical work 2. Analytical formulation of the linear and nonlinear programming problems and solve them with a universal software (Mathcad, VisualDOC, EDAOpt) 3. Practical work 3. The optimization of practical tasks of mechanical system reliability, cost improvements, including criteria and constraint formulation and use of universal software. 4. Practical work 4. Optimization of mechanical system with oscillation frequency limitqation. 5. Practical work 5. Construction cost minimization.
Recommended literature	J. Arora " Introduction to Optimum Design". Second Edition,Elsevier (Academic Press), 2004 M. A. Bhatti "Practical Optimization Methods: With Mathematica Applications", Springer, 2000. J. Auziņš, A. Januševskis "Eksperimentu plānošana un analīze", RTU, 2007. A. Ravindran, K. M. Ragsdell, and G. V. Reklaitis "Engineering Optimization: Methods and Applications", Wiley, 2006.
Course prerequisites	Mathematics. Mechanics. Physics.

Course outline

Theme	Hours
Finding an analytical function extreme. Local extreme and saddle points. Fibonacci and Golden section method. Pr. work 1	3
General formulation of optimization problem. The criterion and constraints, their classification.	3
Gradient, Hessian, KKT conditions. Lagrange multipliers. Global and local optimum. Convex area and convex functions.	3
Linear programming, simplex method. Discrete tasks. Excel application for linear programming tasks. Pr. work 2.	3
Response surface method. The use of optimization for approximation. Least square method. EDAOpt program. Practical work 3	3
Numerical methods of NLP - relaxation, gradient, simplex method. Geometric interpretation. Convergence of numerical methods	3
Conjugate gradient, Fletcher-Powell method, its applications. Introduction to Mathcad optimization opportunities. Pr. Work 4.	3
Compliance with constraints - the gradient projection method. Hard and poorly defined systems	3
Penalty and barrier methods for constrained optimization. VisualDOC program. Practical work 5.	3
Methods of global optimization: multistart, simulated annealing, massive ball, particle swarm, GP, taboo search.	3

Handling with constraints to find initial solution. The exchange of criteria and constraint functions. Coursework	3
Introduction in multiobjective optimization. Weighting factor's method. Pareto frontier.	3
General form of optimal control tasks. Functionals. Lagrangian method. Pontryagin maximum principle pontryagin. Pr. Work 6	3
Sensitivity of optimum and principle of robust optimization.	3
Optimization and identification. The use of optimization for the analysis of experiments. Coursework development.	3
Repeating the course content and exam themes. Developing and organizing of the coursework.	3

Learning outcomes and assessment

Learning outcomes	Assessment methods
Students will be able to apply analytical optimization methods to solve the simplest tasks.	Practical work/tasks
Students will be proficient in the widely available optimization software.	Practical work/tasks
Students will be able to formulate and solve nonlinear optimization tasks of the average complexity degree using the commercial software packages.	Questions in the coursework
Students will be proficient in formulating/stating different optimization problems.	Exam
Students will be able to choose the best method for the solution of linear, nonlinear, discrete and dynamic programming problems.	Exam
Students will be able to assess the complexity and difficulty of different optimization task statements and solutions.	Exam

Study subject structure

Part	CP	ECTS	Hours per Week			Tests		
			Lectures	Practical	Lab.	Test	Exam	Work
1.	4.0	6.0	2.0	1.0	0.0		*	