RTU Course "Numerical Analysis for Research of Dynamics of Machines (for Master Students)"

15325 Teorēt.mehānikas un materiālu pretestības katedra

General data

Code	MTH504
Course title	Numerical Analysis for Research of Dynamics of Machines (for Master Students)
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	Auziņš Jānis
Volume of the course: parts and credits points	1 part, 4.0 Credit Points, 6.0 ECTS credits
Language of instruction	LV, EN, RU, DE
Possibility of distance learning	Not planned
Maximum auditorium capacity	25
Maximum number of students per semester	50
Abstract	This is the basic course on the use of numerical methods for the analysis and optimization of machine and mechanism dynamics. In the present field the researchers have to deal with complex problems of numerical mathematics, which demand the proficiency level above the average and is not limited to knowledge of the basic math course. The main topics of the study subject are: Ideology of engineering calculation. Preciseness/Exactress, stability, complexity, automation. Analysis of linear systems of freguency and time diapason. Methods of analysis of nonlinear systems. Stability of numerical methods. Hard and badly defined systems. Covered methods. Meshanisms with geometrical sites: differential - algebrical systems. Analysis of machine regulation systems. Simplifying the dynamical models. Programms: MathCad, WorkingModel, MSC ADAMS.
Goals and objectives of the course in terms of competences and skills	The aim of the course is to attain the ability to apply the numerical methods for the analysis and optimization of machines, mechanisms and other complex mechanical systems, implemented in universal computer software. After completing this course, students will be able to: (1) estimate the complexity and costs of simulation or optimization tasks as well as predict the main problems before the implementation of the work; (2) be able to use universial software MathCad, specified software WorkingModel, ADAMS/View for simulation of mecanisms and machines and to choose the best of available software and method for solving of given problem.
Structure and tasks of independent studies	Within the framework of the present study subject the students should perform independent work on the following themes: 1. Numerical approximation of analytical functions and given experimental data; 2. Modal analysis of linear oscillation system; 3. Fast Fourier analysis of oscillating system; 4. Numerical solution of given system of ODE; 5. Each student must complete a coursework, providing a simulation of mechanism performing 3 DOF and considering electrodrive and PID control system.
Recommended literature	1. S.C. Chapra, R. P. Canale Numerical Methods for Engineers, Fifth edition, Mc Graw Hill, 2006 2. А. И. Панферов, А.В. Лопрарев, В.К. Пономарев Применение MathCad в инженерных расчетах: Учебное пособие. СПбГУАП, СПб. 2004 3. T.L. Harman, J. B. Dabney, N.J. Richert Advanced Engineering Mathematics with Matlab. Brooks/Cole, 2000.
Course prerequisites	Mathematics, theoretical mechanics, computer-aided analysis of mechanisms - basic course

Course outline

Theme	Hours
1. Linear algebra equations. Direct Methods. Iterative Methods	4
2. Eigenvalue problems for linear systems	4
3. Numerical solution of nonlinear equations.	4
4. Interpolation and finite differences.	4
5. Interpolation and approximation with orthogonal polynomials.	4
6. Numerical differentiation.	4
7. Numerical integration. Newton Cotes and Gaussian integration formulas	4
8. Numerical Solution of ODE. The modified Euler method.	4
9. Adam's, Runge-Kutta and multistep methods.	4
10. Accuracy and stability of ODE solution. Regions of stability.	4
11. Stiff systems. Implicit methods. Methods for FEM dynamic simulation.	8
12.Discrete and Fast Fourier transforms	4

13.Global parametric optimization. Gradient and second order methods.	4
14. Software packages. MathCad, WorkingModel, MSC ADAMS/View	8

Learning outcomes and assessment

Learning outcomes	Assessment methods
1. Understad the concept of the sources of calculation errors and stability	Questions at the exam
2. Be aware of the main interpolation and approximation methods of functions	Questions at the exam
3. Know the main direct and iterative methods for solving of systems of linear algebraic equations	Questions at the exam
4. Understand the modal analysis of linear systems	Questions at the class and in home works
5. Know the main methods of numerical integration and differentiation of functions	Questions at the exam
6. Know the mainly used methods of numerical solving of ODE systems	Questions in the home works
7. Understand the stability of numerical methods for solving of ODE	Questions at the exam
8. Be able to use commercial software for numerical methods	Questions in the practical works and in the coursework.

Study subject structure

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