RTU Course "Nonlinear Dynamics and Chaos"

15325 Teorēt.mehānikas un materiālu pretestības katedra

General data

Code	MMP538
Course title	Nonlinear Dynamics and Chaos
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	Zakrževskis Mihails
Volume of the course: parts and credits points	1 part, 4.0 Credit Points, 6.0 ECTS credits
Language of instruction	LV, EN, RU
Possibility of distance learning	Not planned
Maximum auditorium capacity	15
Maximum number of students per semester	30
Abstract	Nonlinear dynamics and chaos is a new multidisciplinary fundamental science for engineers, which has a major theoretical and empirical importance. The basics of nonlinear Dynamics and Chaos: attractors; bifurcations, basins of attraction; solution continuation, chaos and control. Analytical, numerical and experimental research methods. The method of complete bifurcation groups. Rare regular and chaotic phenomena. Multiplicity. Modern software: NLO, Spring, AUTO, Dynamics, Matcont. Applications: technical catastrophes prediction and prevention, control tasks, vibromechanics, electromechanics, cosmology, ecology, medicine.
Goals and objectives of the course in terms of competences and skills	The goal of the course is to help students to acquire skills required to analyze nonlinear dynamical systems of different nature applying modern methods. The objective of the course is to help students to acquire competence to analyze the behavior of typical nonlinear dynamical systems and apply this knowledge to other courses
Structure and tasks of independent studies	Studying of main study course themes consulting the recommended literature. Individual and group (2-3) mini-projects on Nonlinear Dynamics and Chaos. Tutorials
Recommended literature	1. Francis C. Moon. Chaotic Vibrations. An Introduction for Applied Scientists and Engineers, Wiley, 2004. 2. James Gleick. Chaos. Making a New Science, 1987. 3. Джеймс Глейк, Хаос. Создание новой науки, Амфора, 2001 4. Steven H. Strogatz. Nonlinear Dynamics and Chaos, Westview Press, 2000. 5. M. Zakrzhevsky. New concepts of nonlinear dynamics: complete bifurcation groups, protuberances, unstable periodic infinitiums and rare attractors J. of Vibroengineering, Vol. 10, Issue 4, p. 421-441, 2008. 6. Yoshisuke Ueda. The Road to Chaos - II, Aerial Press, 2001. 7. В.С. Анищенко. Сложные колебания в простых системах, Либроком, 2009. 8. Jon J. Thomsen. Vibrations and Stability. Advanced Theory, Analysis, and Tools, Springer, 2003. 9. Miguel A.F. Sanjuan, Celso Grebogi. Recent Progress in Controlling Chaos, World Scientific, 2010. 10. R. Kent Nagle, Edward B. Saff. Fundamentals of Differential equations and Boundary Value Problems, Addison-Wesley, 1993. 11. Programmatura: NLO, Spring, AUTO, Dynamics, Matcont
Course prerequisites	Mathematics. Physics. Mechanics. Computer science

Course outline

Theme	Hours
Subject of Nonlinear Dynamics and Chaos. Typical models	4
Free oscillations of strongly nonlinear systems	4
Methods of nonlinear dynamics. Poincare method. Attractors and types of attractors	8
Driven oscillations in systems with polynomial restoring force. Multiplicity	4
Line mapping. Contour mapping. Direct and indirect mapping	4
Stability of nonlinear dynamical systems. Lyapunov stability. Stability in large. Basins of attraction	8
Subharmonic oscillations. Subharmonics in case of strong dissipation	4
Method of complete bifurcation groups	4
Non-smooth and vibro-impact systems. Simplest models: bilinear, trilinear, vibro-impact with one- and two-side limiter	8
Paradoxes of linear and nonlinear non monotonous damping	8
General features of nonlinear dynamical systems. Chaotic attractors and chaotic transient	4
Applications and control	4

Learning outcomes and assessment

Learning outcomes	Assessment methods
Ability to carry out research of nonlinear dynamical systems using analytical/numerical and experimental methods	Individual and group (2-3) mini-projects
Knowledge of modern research methods for nonlinear dynamical systems	Exam
Knowledge of general regularity in nonlinear dynamical systems	Exam

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		*	