**DAUGAVPILS UNIVERSITY**

**DESCRIPTION OF THE STUDY COURSE**

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| Name of study course | Selected issues of mathematical modelling II |
| Code of study course (DUIS) | MateD043 |
| Scientific branch | Mathematics |
| Course level | 7 |
| Credits | 2 |
| ECTS credits | 3 |
| Total contact hours | 16 |
| Number of lecture hours | 8 |
| Number of seminar hours | 8 |
| Hours of practical work | - |
| Hours of laboratory work | - |
| Number of hours of independent work | 64 |
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| Course author(-s) | |
| Dr.math., Professor Felikss Sadirbajevs (DU) | |
| Course docent(-s) | |
| Dr.math., Associated Professor Armands Gricāns (DU) Dr.math., Professor Felikss Sadirbajevs (DU) | |
| Prior knowledge | |
| MateD012,   MateD014,   MateD015 | |
| Annotation of the study course | |
| The aim of the course is to provide knowledge about complex systems, the behaviour of their solutions and methods of investigation. To introduce the self-organization of complex systems, to introduce the new concept of synergy.  Course tasks:  - to acquire knowledge of complex systems, their mathematical modelling;  - to acquire knowledge of the self-organization of complex systems;  - to acquire knowledge of biological models of populations, and types of biological populations. | |
| Calendar plan of the study course | |
| Course structure: lectures (L) - 8 hrs, seminars (S) - 8 hrs, students' independent work (Pd) - 64 hrs.  1. Chemical reactions in open and closed systems. Autocatalysis. (L2, Pd8)  2. Bifurcations. Bifurcations in 2-dimensional systems. (L2, Pd8)  3. Order and chaos. One-dimensional representations. (S2, Pd8)  4. Lorentz equation. Attractors. (L2, Pd8)  5. Reaction-diffusion dynamics. Fisher equation. (L2, Pd8)  6. Spatial formation. (S2, Pd8)  7. Solitons. Korteweg-de Vries equation. Sine-Gordon equation. (S2, Pd8)  8. FitzHugh-Nagumo equation, Hodgkin-Huxley equation. (S2, Pd8) | |
| Study outcomes | |
| Knowledge:   1. Is familiar with chemical reactions and their mathematical description. 2. Is familiar with bifurcations in 2-dimensional systems of differential equations. 3. Is familiar with the concepts of order, chaos, spatial organization, self-organization.   Skills:   1. Is able to recognize the solution of bifurcations in systems of two-dimensional differential equations. 2. Is able to understand the meaning of mathematical models involving the Fisher equation, the Korteweg-de Vries equation, the Sine-Gordon equation, the FitzHugh-Nagumo equation, the Hodgkin-Huxley equation. 3. Is able to numerically investigate the Lorentz equation, understand the sensitive dependence of solutions on initial data.   Competence:   1. Actively participates in discussions about order and chaos, the role of chaos in natural processes. 2. Independently develops own competence by identifying current trends in studying biological processes. | |
| Description of the organization and tasks of students' independent work | |
| Students carry out 3 independent works on the following topics:   1. analysis of non-linear equation bifurcations; 2. soliton calculations in the Korteweg-de Vries equation; 3. identification of chaos in the proposed differential equation. | |
| Requirements for obtaining credits | |
| CRITERIA FOR EVALUATING THE LEARNING OUTCOMES  The acquisition of the study course is evaluated by using 10-point scale according to the laws and regulations of the Republic of Latvia and in accordance with the "Regulations on studies at Daugavpils University" (approved at DU Senate meeting on 17.12.2018., Minutes No. 15), based on the following evaluation criteria of learning outcomes: the scope and quality of acquired knowledge, acquire skills and competencies in accordance with the planned study results.  EVALUATION OF LEARNING OUTCOMES   |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | | Type of test | Learning outcomes | | | | | | | | | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | | 1. Independent work I | + |  |  |  |  |  | + |  | | Independent work I |  | + | + | + |  | + |  | + | | Independent work I |  | + |  |  | + | + | + | + | | Test | + | + | + | + | + | + | + | + |   Final differentiated test assessment. The mark is calculated as the average mark of the independent work. | |
| Course content | |
| 1. . Chemical reactions in open and closed systems. Autocatalysis. (L2, Pd8)  2. Bifurcations. Bifurcations in 2-dimensional systems. (L2, Pd8)  3. Order and chaos. One-dimensional representations. (S2, Pd8)  4. Lorentz equation. Attractors. (L2, Pd8)  5. Reaction-diffusion dynamics. Fisher equation. (L2, Pd8)  6. Spatial formation. (S2, Pd8)  7. Solitons. Korteweg-de Vries equation. Sine-Gordon equation. (S2, Pd8)  8. FitzHugh-Nagumo equation, Hodgkin-Huxley equation. (S2, Pd8) | |
| Mandatory sources of information | |
| 1. M.W. Hirsch, S. Smale, R.L. Devaney.Differential equations, Dynamical ystems, and An introduction To chaos. Elsevier, 2004. 2. L. Peletier, W.Troy.  [**Spatial Patterns**](https://biblio.du.lv/Alise/lv/book.aspx?id=35538&ident=1028284). Birkhauser, 2001. 343 p. 3. L. Perko, Lawrence [**Differential Equations and Dynamical Systems**](https://biblio.du.lv/Alise/lv/book.aspx?id=47747&ident=1045210) Springer, 2001. 551 p. | |
| Additional sources of information | |
| 1. E.S. Allman, J.A. Rhodes. Mathematical Models in Biology: An Introduction, Cambridge University Press, 2003. 2. P. Blanchard, R. Devaney, G. Hall. Differential Equations, Fourth Edition. Published by Brooks/Cole, Cengage Learning, 2011. ISBN 13: 978-0-495-56198-9. 3. V. Benci et al. Variational and Topological Methods in the Study of Nonlinear Phenomena, Birkhäuser, 2002. 4. R.S. Cantrell, C. Cosner. Spatial Ecology via Reaction-Diffusion Equations (Wiley Series in Mathematical & Computational Biology), Wiley, 2003. 5. R.H. Enns. It's a Nonlinear World (Springer Undergraduate Texts in Mathematics and Technology), Springer, 2010. 6. B. Ferguson. Dynamic Economic Models in Discrete Time: Theory and Empirical Applications, Routledge, 2003. 7. J.-P. Françoise. Oscillations en biologie: Analyse qualitative et modèles (Mathématiques et Applications), Springer, 2005. 8. R.J. Hosking, E. Venturino. Aspects of Mathematical Modelling: Applications in Science, Medicine, Economics and Management (Mathematics and Biosciences in Interaction), Birkhauser Basel, 2008. 9. D.S. Jones, B.D. Sleeman. Differential Equations and Mathematical Biology, Chapman & Hall/CRC, 2003. 10. C.H. Skiadas, C. Skiadas. Chaotic Modelling and Simulation: Analysis of Chaotic Models, Attractors and Forms, Chapman&Hall/CRC, 2008. 11. J.J. Stoker. Nonlinear Vibrations in Mechanical and Electrical Systems, Wiley, 1992. | |
| Periodicals and other sources of information | |
| 1. **Real World Examples of Mathematical Modelling**  [Real World Examples of Mathematical Modelling - Maths Careers](https://www.mathscareers.org.uk/real-world-examples-of-mathematical-modelling/) | |
| Notes | |
| Part A of the doctoral study program "Mathematics".  The course is taught in Latvian or English. | |