**DAUGAVPILS UNIVERSITY**

**DESCRIPTION OF THE STUDY COURSE**

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| Name of study course | Selected issues of mathematical modelling I |
| Code of study course (DUIS) | MateD011 |
| 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)  Dr.math., Associated Professor Ināra Jermačenko (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 of classical mathematical models. Particular attention will be paid to models involving non-linear oscillations.  Course tasks:  - to acquire knowledge of models of second-order mechanics;  - to acquire knowledge of Hamiltonian 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. Second-order mechanics models. Harmonic oscillations. Oscillations with brake force. Oscillations due to periodic forces. (L2, Pd8)  2. Duffing equation. Non-linear oscillations. (L2, Pd8)  3. Van-der-Pol equation. Non-linear oscillations in radio engineering. Limit cycle. (S2, Pd8)  4. Levene's equation. Energy conservation and dissipation. Periodic rings and limit cycles. (L2, Pd8)  5. Hamiltonian systems. (L2, Pd8)  6. Examples of non-linear oscillators (after [R.E. Mickens]). (S2, Pd8)  7. Relaxation oscillations. Current-induced oscillations of neurons. (S2, Pd8)  8. Population biological models. Symbiosis, competition, predator-prey models. (S2, Pd8) | |
| Study outcomes | |
| Knowledge:   1. Is familiar with second-order mechanics models and linear oscillations. 2. Is familiar with non-linear oscillations, the Duffing, Lie´nard and Van-der-Pol differential equations. 3. Knows examples of biological population models.   Skills:   1. Is able to use second-order linear differential equations to model mechanical systems under the influence of braking forces and/or periodic forces. 2. Is able to analyze the differential equations of Duffing, Lienard and Van-der-Pohl. Understands the amplitude-period relationship in non-linear oscillations. 3. Is able to analyze models of biological populations.   Competence:   1. Actively participates in discussions on linear and non-linear oscillations and their mathematical modelling. 2. Independently develops own competence by identifying current trends in mathematical modelling in biology. | |
| Description of the organization and tasks of students' independent work | |
| Students carry out 3 independent works on the following topics:   1. linear oscillations; 2. non-linear oscillations; 3. biological population modelling. | |
| 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. | | Independent work I | + |  |  |  |  | + | + |  | | Independent work II | + | + | + | + |  |  |  | + | | Independent work III |  |  |  |  | + | + | + | + | | Test | + | + | + | + | + | + | + | + |   Final differentiated test assessment. The mark is calculated as the average mark of the independent work. | |
| Course content | |
| 1. Second-order mechanics models. Harmonic oscillations. Oscillations with brake force. Oscillations due to periodic forces. (L2, Pd8)  2. Duffing equation. Non-linear oscillations. (L2, Pd8)  3. Van-der-Pol equation. Non-linear oscillations in radio engineering. Limit cycle. (S2, Pd8)  4. Levene's equation. Energy conservation and dissipation. Periodic rings and limit cycles. (L2, Pd8)  5. Hamiltonian systems. (L2, Pd8)  6. Examples of non-linear oscillators (after [R.E. Mickens]). (S2, Pd8)  7. Relaxation oscillations. Current-induced oscillations of neurons. (S2, Pd8)  8. Population biological models. Symbiosis, competition, predator-prey models. (S2, Pd8)  Independent work - 64 acad. h. Students complete 3 independent works, the average mark of which is the differentiated credit mark. | |
| Mandatory sources of information | |
| 1. S. Ahmad, A. Ambrosetti. A Textbook on Ordinary Differential Equations, Springer, 2014. 2. L. Peletier, W.Troy. [**Spatial Patterns**](https://biblio.du.lv/Alise/lv/book.aspx?id=35538&ident=1028284): Higher Order Models in Physics and Mechanics, Birkhäuser, 2001. 3. L. Perko. Differential Equations and Dynamical Systems, Springer, 3rd Edition, 2006. 4. T. Witelski, M. Bowen. Methods of Mathematical Modelling. Springer, 2015. | |
| Additional sources of information | |
| 1. E.S. Allman, J.A. Rhodes. Mathematical Models in Biology: An Introduction, Cambridge University Press, 2003. 2. R.S. Cantrell, C. Cosner. Spatial Ecology via Reaction-Diffusion Equations (Wiley Series in Mathematical & Computational Biology), Wiley, 2003. 3. R.H. Enns. It's a Nonlinear World (Springer Undergraduate Texts in Mathematics and Technology), Springer, 2010. 4. B. Ferguson. Dynamic Economic Models in Discrete Time: Theory and Empirical Applications, Routledge, 2003. 5. J.-P. Françoise. Oscillations en biologie: Analyse qualitative et modèles (Mathématiques et Applications), Springer, 2005. 6. R.J. Hosking, E. Venturino. Aspects of Mathematical Modelling: Applications in Science, Medicine, Economics and Management (Mathematics and Biosciences in Interaction), Birkhauser Basel, 2008. 7. D.S. Jones, B.D. Sleeman. Differential Equations and Mathematical Biology, Chapman & Hall/CRC, 2003. 8. J.D. Murray. Mathematical Biology: I. An Introduction (Interdisciplinary Applied Mathematics), Springer, 2007. 9. J.D. Murray. Mathematical Biology. II Spatial Models and Biomedical Applications, Springer, 2003. 10. C.H. Skiadas, C. Skiadas. Chaotic Modelling and Simulation: Analysis of Chaotic Models, Attractors and Forms, Chapman&Hall/CRC, 2008. | |
| Periodicals and other sources of information | |
| 1. V. Benci et al. Variational and Topological Methods in the Study of Nonlinear Phenomena, Birkhäuser, 2002. | |
| Notes | |
| Part A of the doctoral study program "Mathematics".  The course is taught in Latvian or English. | |