**AUGAVPILS UNIVERSITY**

**DESCRIPTION OF THE STUDY COURSE**

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| Name of study course | Contemporary methods in the theory of boundary value problems for ordinary differential equations II |
| Code of study course (DUIS) | MateD038 |
| Scientific branch | Mathematics |
| Course level | 7 |
| Credits | 2 |
| ECTS credits | 3 |
| Total contact hours | 16 |
| Number of lecture hours | 12 |
| Number of seminar hours | 4 |
| 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, MateD018 | |
| Annotation of the study course | |
| The aim of the course is to provide further knowledge of boundary value problems for ordinary differential equations. It covers spectral problems, types of solutions and the basics of qualitative theory of two-dimensional systems. Elements of topological degree theory and Leray-Schauder theory are worked with.  Course tasks:  - to become familiar with ordinary differential equations for spectral boundary value problems;  - to become familiar with the theory of Leray-Schauder;  - to become familiar with topological degree theory, rotation of vector fields in the plane;  - learn about the phase plane method and the basics of Poincaré-Bendixson theory;  - to study a specific differential equation problem of the teacher's choice. | |
| Calendar plan of the study course | |
| Course structure: lectures (L) - 12 hrs, seminars (S) - 4 hrs, students' independent work (Pd) - 64 hrs.  1. Spectral challenges. The Sturm-Lewis problem. (L2, Pd8)  2. Types of solutions. (L2, Pd8)  3. Phase plane method. Fundamentals of the Poincaré-Bendixson theory. (L2, Pd8)  4. Periodic solutions for 2D systems. Rings and limit cycles. (S2, Pd8)  5. Investigation of 3D systems. Stable and unstable varieties. (L2, Pd8)  6. Elements of Leray-Schauder theory, homotopies. (L2, Pd8)  7. Topological degree theory and its applications. (L2, Pd8)  8. Topical issues (teacher's choice). (S2, Pd8) | |
| Study outcomes | |
| Knowledge:   1. Is familiar with spectral problems in the theory of boundary value problems for ordinary differential equations. 2. Is familiar with the fundamentals of Poincaré-Bendixson theory;. 3. Acquires knowledge of the rotation of vector fields; 4. Is introduced to the elements of the Lere-Schauder theory; 5. Is introduced to the topological degree theory and their application;   Skills:   1. Is able to find the short values of a spectral problem. 2. Is able to define the critical point type of differential equations. 3. Is able to apply Lere-Schauder theory to prove the existence of a solution. 4. Is able to calculate the rotation of a given vector field.   Competence:   1. Actively participates in discussions on topological degrees of representations and their applications to proving the existence of solutions to problems. 2. Independently develops own competence by identifying current trends in the study of the phase space structure of higher order systems. | |
| Description of the organization and tasks of students' independent work | |
| Students carry out 3 independent works on the following topics:   1. Vector field rotation calculation; 2. Design of limit cycle and periodic ring; 3. Proof of the existence of a solution to a given boundary value problem using Lere-Schauder theory. | |
| 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. | 9. | 10. | 11. | | 1. 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. Spectral challenges. The Sturm-Lewis problem. (L2, Pd8)  2. Types of solutions. (L2, Pd8)  3. Phase plane method. Fundamentals of the Poincaré-Bendixson theory. (L2, Pd8)  4. Periodic solutions for 2D systems. Rings and limit cycles. (S2, Pd8)  5. Investigation of 3D systems. Stable and unstable varieties. (L2, Pd8)  6. Elements of Leray-Schauder theory, homotopies. (L2, Pd8)  7. Topological degree theory and its applications. (L2, Pd8)  8. Topical issues (teacher's choice). (S2, Pd8) | |
| Mandatory sources of information | |
| 1. P. Amster. Topological Methods in the Study of Boundary Value Problems. Springer, 2014. 2. M. Hirsh, S. Smale, R. Devaney. Differential equations, dynamical systems, and an introduction to chaos. Elsevier, 2004. 3. M.A. Krasnoselskii et al. Plane vector fields, 1966. 4. N. Lloyd. Topological degree, Cambridge University Press, 1978. | |
| Additional sources of information | |
| 1. C. Chicone. Ordinary Differential Equations With Applications, Springer, 1999. 2. J. Dugundji, A. Granas. Fixed Point Theory, Springer, 2003. 3. A.Granas, R. Guenther, J. Lee. Nonlinear boundary value problems for ordinary differential equations. – Warszawa, Polish Sci. Publ., 1985. 4. D. Jordan, P. Smith. Nonlinear Ordinary Differential Equations: An Introduction for Scientists and Engineers (Oxford Texts in Applied and Engineering Mathematics), Oxford University Press, 2007. 5. J. Leray et J. Schauder. Topologie et équations fonctionnelles. Annales de École Norm. sup., 13 (1934), 45 –78. 6. J. Mawhin. Topological degree methods in nonlinear boundary value problems. – Reg. conf. series in math., # 40. AMS publication. 1977. 7. D. O'Regan D., Y.J. Cho, Y.-Q Chen. Topological degree theory and applications (Series in Mathematical Analysis and Applications), Volume 10, 2006. 8. D. O'Regan, R. Precup. Theorems of Leray-Schauder Type And Applications (Series in Mathematical Analysis and Applications), Volume 3, CRC, 2002. | |
| Periodicals and other sources of information | |
| 1. K. Schmit, R.C. Thompson. Nonlinear Analysis and Differential Equations. An Introduction <http://www.math.utah.edu/~schmitt/ode1.pdf> | |
| Notes | |
| Part A of the doctoral study program "Mathematics".  The course is taught in Latvian or English. | |