Univerza v Mariboru

Fakulteta za naravoslovje in matematiko

| UČNI NAČRT PREDMETA / COURSE SYLLABUS | |
|---|---|
| **Predmet:** | Diferencialne enačbe |
| **Course title:** | Differential Equations |

| Študijski program in stopnja<br>Study programme and level | Študijska smer<br>Study field | Letnik<br>Academic year | Semester<br>Semester |
|---|---|---|---|
| **Matematika, 3. stopnja** | | **1.** | **2.** |
| **Mathematics, 3rd cycle** | | **1st** | **2nd** |

**Vrsta predmeta / Course type** izbirni / elective

**Univerzitetna koda predmeta / University course code:**

| Predavanja<br>Lectures | Seminar<br>Seminar | Vaje<br>Tutorial | Klinične vaje<br>work | Druge oblike študija | Samost. delo<br>Individ. work | ECTS |
|---|---|---|---|---|---|---|
| **45** | | | | | **225** | **9** |

**Nosilec predmeta / Lecturer:** Valerij Romanovskij

| **Jeziki / Languages:** | **Predavanja / Lectures:** | Slovenski / Slovene |
|---|---|---|
| | **Vaje / Tutorial:** | |

| **Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:** | **Prerequisits:** |
|---|---|
| Znanje osnovnih pojmov in rezultatov iz teorije NDE | Basic knowledge of fundamental notions and results of the theory of ODE's |

**Vsebina:**

- diferencialne enačbe 2. reda
- približne rešitve linearnih diferencialnih enačb
- približne rešitve nelinearnih diferencialnih enačb
- reguarna in singularna perturbacijska teorija
- perturbacijske metode za probleme lastnih vrednosti
- aproksimacije WKB
- tokovi in invariantni podprostori
- funkcije Ljapunova
- normalne forme diferencialnih enačb in preslikav
- bifurkacije ravnovesne lege
- bifurkacije periodičnih orbit
- izohronost nihanj
- uvod v kaos

**Content (Syllabus outline):**

- second order ODEs
- approximate solutions of linear differential equations
- approximate solutions of nonlinear differential equations
- regular and singular perturbation theory
- perturbations methods for the eigenvalues problem
- WKB approximations
- flows and invariant subspaces
- Lyapunov functions
- normal forms of differential equations and maps
- bifurcations of singular points
- bifurcations of periodic orbits
- isochronicity of oscillations
- an introduction to chaos

**Temeljni literatura in viri / Readings:**


- D.K. Arowsmith, C. M. Place, Dynamical systems. Diferential equations, maps an chaotic behaviour, Chapman and Hall Mathematics Series, Chapman & Hall, London 1992.
- C. M. Bender, S. A. Orszag, Advanced mathematical methods for scientists and engineers, International series in pure and applied mathematics, McGraw-Hill Book Co., New York 1978.
- S. N. Chow, J. K. Hale, Methods of bifurcation theory, Grundlehren der Mathematischen wissenschaften, 251. Springer-Verlag, New York – Berlin 1982.
- F. Dumortier, J. Llibre, J.C. Artes, Qualitative Theory of Planar Differential Systems, Springer Verlag, Barlin, 2006.
- J. A. Murdock, Normal forms and unfoldings for local dynamical systems, Springer, New York, 2003
- V. G. Romanovski, D. S. Shafer, The Center and Cyclicity Problems A Computational Algebra Approach. Birkhäuser, Boston, 2009


**Cilji in kompetence:**

- Razumevanje osnovnih načinov kvalitativne in bifurkacijske analize diferencialnih enačb
- Poznavanje metod študija lastnosti rešitev diferencialnih enačb in gladkih preslikav
- Pridobiti si sposobnost detajlne analize določenih matematičnih modelov opisanih z navadnimi diferencialnimi enačbami ali gladkimi preslikavami
- Razviti sposobnost samostojnega razvijanja novega znanja s področja diferencialnih enačb
- Zmožnost razvijanja kritične refleksije na področju diferencialnih enačb
- Razviti zmožnost vodenja najzahtevnejših znanstvenoraziskovalnih projektov s širšega področja diferencialnih enačb.

**Objectives and competences:**

- Understanding main approaches to the qualitative and bifurcational analysis of differential equations
- Gaining knowledege of methods of studying the properties of solutions of differential equations and smooth maps
- Gaining skills of detail analysis of certain mathematical model described by ordinary differential equations or smoth maps
- To develop the ability to independently develop new knowledge in the field of differential equations
- Ability to develop critical reflection in differential equations
- To develop the ability to lead the most challenging scientific research projects in the wider field of differential equations

| **Predvideni študijski rezultati:** | **Intended learning outcomes:** |
|---|---|
| Znanje in razumevanje:<br><br>• Razumevanje metod kvalitativne in bifurkacijske analize dinamičnih sistemov<br>• Pridobivanje sposobnosti sistematskega študija rešitev dinamičnih sistemov in njihovih lastnosti.<br><br>• Sposobnost uporabe znanja za študij matematičnih modelov različnih procesov in pojavov v fizikalni, tehnični in drugih uporabnih znanosti<br>• Sposobnost razumevanja in analiziranja dinamičnih procesov opisanih diferencialnimi enačbami in gladkimi preslikavami | Knowledge and understanding:<br><br>• Understanding of methods of qualitative and bifurcational analysis of dynamical systems<br>• Gaining some systematic approaches to studying of solutions of dynamical systems and their properties<br><br>• The ability to use of knowledge for studying of mathematical models of various processes and phenomena arising in physical, technical and other applied sciences<br>• The ability to understand and analyze the dynamics of processes described by differential equations and smooth maps |

| **Metode poučevanja in učenja:** | **Learning and teaching methods:** |
|---|---|
| • predavanja;<br>• priprava seminarja;<br>• konzultacije;<br>• samostojni študij. | • lectures;<br>• seminar work;<br>• consultations;<br>• self-study. |

| **Načini ocenjevanja:** | Delež (v %) / Weight (in %) | **Assessment:** |
|---|---|---|
| Način (pisni izpit, ustno izpraševanje, naloge, projekt): | | Type (examination, oral, coursework, project): |
| • seminarsko predavanje;<br>• pisni izpit;<br>• ustno izpraševanje. | **20%**<br>**30%**<br>**50%** | • seminar talk;<br>• written work;<br>• oral examination. |

**Reference nosilca / Lecturer's references:**

**1.** ARCET, Barbara, ROMANOVSKI, Valery. Integrability and linearizability of symmetric three-dimensional quadratic systems. *Discrete and continuous dynamical systems. Series S*. April 2022, 18 str. ISSN 1937-1632. DOI: 10.3934/dcdss.2022104. [COBISS.SI-ID 130109955], [JCR, SNIP, WoS, Scopus]
kategorija: 1A2

**2.** LI, Yongjun, ROMANOVSKI, Valery. Hopf bifurcations in a predator - prey model with an omnivore. *Qualitative theory of dynamical systems*. Dec. 2019, vol. 18, iss. 3, str. 1201-1224. ISSN 1575-5460. https://link.springer.com/article/10.1007%2Fs12346-019-00333-9, DOI: 10.1007/s12346-019-00333-9. [COBISS.SI-ID 47367683], [JCR, SNIP, WoS]
kategorija: 1A1

**3.** ZHENGXIN, Zhou, ROMANOVSKI, Valery. The center problem and the composition condition for a family of quartic differential systems. *Electronic journal of qualitative theory of differential*

*equations*. 2018, vol. 2018, no. 15, str. 1-17. ISSN 1417-3875. DOI: 10.14232/ejqtde.2018.1.15. [COBISS.SI-ID 21365270], [JCR, SNIP, WoS
kategorija: 1A1

**4.** GINÉ, Jaume, ROMANOVSKI, Valery, TORREGROSA, Joan. Time-reversibility and integrability of p : -q resonant vector fields. *AIMS mathematics*. 2024, vol. 9, iss. 1, str. 73-88. ISSN 2473-6988. DOI: 10.3934/math.2024005. [COBISS.SI-ID 184528899], [JCR]
kategorija: 1A1

**5.** ARCET, Barbara, GINÉ, Jaume, ROMANOVSKI, Valery. Linearizability of planar polynomial Hamiltonian systems. *Nonlinear analysis: real world applications*. Feb. 2022, vol. 63, 19 str. ISSN 1468-1218. DOI: 10.1016/j.nonrwa.2021.103422. [COBISS.SI-ID 110154755], [JCR]
kategorija: 1A1