Univerza v Mariboru

Fakulteta za naravoslovje in matematiko

| UČNI NAČRT PREDMETA / COURSE SYLLABUS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Predmet:** | **Numerična analiza in izbrana poglavja iz dinamičnih sistemov** | | | | | | | |
| **Course title:** | **Numerical Analysis and Selected Topics from the Theory of Dynamical Systems** | | | | | | | |
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| **Študijski program in stopnja<br>Study programme and level** | | **Študijska smer<br>Study field** | | | **Letnik<br>Academic year** | | **Semester<br>Semester** | |
| Matematika, 2. stopnja | | | | | **1. ali 2.** | | **2. ali 4.** | |
| Mathematics, 2nd degree | | | | | **1. or 2.** | | **2. ali 4.** | |
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| **Vrsta predmeta / Course type** | | | | obvezni / compulsory | | | | |
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| **Univerzitetna koda predmeta / University course code:** | | | | | | | | |
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| **Predavanja<br>Lectures** | **Seminar<br>Seminar** | **Sem. vaje<br>Tutorial** | **Lab. vaje<br>Laboratory work** | **Teren. vaje<br>Field work** | **Samost. delo<br>Individ. work** | | **ECTS** | |
| **60** | | **30** | **15** | | **195** | | **10** | |
| | | | | | | | | |
| **Nosilec predmeta / Lecturer:** | | Valerij ROMANOVSKIJ | | | | | | |
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| **Jeziki / Languages:** | **Predavanja / Lectures:** | SLOVENSKO/SLOVENE | | | | | | |
| | **Vaje / Tutorial:** | SLOVENSKO/SLOVENE | | | | | | |

| **Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:** | **Prerequisits:** |
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| Poznavanje matematične analize. | Knowledge of mathematical analysis. |

| **Vsebina:** | **Content (Syllabus outline):** |
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| 1. Reševanje nelinearnih enačb. Reševanje sistemov nelinearnih enačb.<br>2. Diferenčni operatorji in diferenčne enačbe.<br>3. Sistemi linearnih enačb. Iterativne metode.<br>4. Problem lastnih vrednosti: Schurov in | 1. Nonlinear equations solving. Systems of nonlinear equations solving.<br>2. Difference equations and difference operators.<br>3. Systems of linear equations. Iterative |

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|---|---|
| Gershgorinov izrek. Simetrični in nesimetrični problem lastnih vrednosti.<br>5. Polinomski sistemi: Groebnerjeva baza. Raznoterost polinomskega ideala in njene lastnosti. Razcep raznoterosti.<br>6. Navadne diferencialne enačbe: Picardova metoda. Metode Runge-Kutta. Večkoračne metode. Robni problem.<br>7. Parcialne diferencialne enačbe.<br>8. Lastnosti rešitev in stabilnost rešitev sistemov navadnih diferencialnih enačb.<br>9. Dvodimenzionalni avtonomni sistemi: Kanonične ravnovesne točke, fazne slike.<br>10. Limitni cikli, bifurkacije.<br>11. Izbrani modeli, opisani z navadnimi diferencialnimi enačbami. | methods.<br>4. Eigenvalues computation problem: Schur's and Gershgorin's theorems. Symmetric and non-symmetric eigenvalue problem.<br>5. Polynomial systems: Groebner basis, variety of polynomial ideal and its properties. Decomposition of varieties.<br>6. Ordinary differential equations: Picard method. Runge-Kutta methods. Multi-step methods. Boundary-value problems.<br>7. Partial differential equations.<br>8. Properties of solutions and stability of solutions of ordinary differential equations.<br>9. Two-dimensional autonomous systems: canonical equilibrium points, phase portraits.<br>10. Limit cycles, bifurcations.<br>11. Selected models described by ordinary differential equations. |

**Temeljni literatura in viri / Readings:**

Z. Bohte, Numerično reševanje nelinearnih enačb, DMFA Slovenije, Ljubljana, 1993.
Z. Bohte, Numerično reševanje sistemov linearnih enačb, DMFA Slovenije, Ljubljana, 1994.
D. Kincaid, W. Cheney: Numerical Analysis, Brooks/Cole, Pacific Grove, 1996.
E. Zakrajšek, Uvod v numerične metode, druga izdaja, DMFA Slovenije, Ljubljana, 2000.
V. G. Romanovski and Douglas S. Shafer, The Center and Cyclicity Problems. A Computational Algebra Approach, Boston-Basel-Berlin: Birkhauser, 2009.
G. Teschl, Ordinary Differential Equations and Dynamical Systems. Providence: American Mathematical Society, 2012.
D. K. Arrowsmith and C.M. Place, Ordinary Differential Equations – A qualitative approach with applications, Chapman and Hall, 1982.
S. Lynch, Dynamical Systems with Applications using Mathematica, Birkhäuser, 2017.

| **Cilji in kompetence:** | **Objectives and competences:** |
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| Poglobiti znanje iz zahtevnejših konceptov in rezultatov s področja numerične analize in simbolnega računanja. Spoznati nekatere metode teorije dinamičnih sistemov. | To deepen the knowledge of more demanding concepts and results from numerical analysis and symbolic computation. To learn some methods from the theory of dynamical systems. |

| **Predvideni študijski rezultati:** | **Intended learning outcomes:** |
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| Znanje in razumevanje: | Knowledge and Understanding: |

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| • Poglobiti znanje iz zahtevnejših numeričnih metod, teorije dinamičnih sistemov in njihovih uporabnih vrednosti.<br>• Prepoznati praktične probleme in njihovo modeliranje z orodji numerične matematike in teorije dinamičnih sistemov.<br><br>Prenesljive/ključne spretnosti in drugi atributi:<br>• Prenos znanja numeričnih metod in dinamičnih sistemov na druga področja (računalništvo, statistika, optimizacija, matematično modeliranje, ...) | • To deepen the knowledge of more demanding numerical methods, the theory of dynamical systems and their applications.<br>• To recognize practical problems and their modeling with numerical mathematics and dynamical systems tools.<br><br>Transferable/Key Skills and other attributes:<br>• Knowledge transfer of numerical methods and the theory of dynamical systems into other fields (computer science, statistics, optimization, mathematical modeling, …) |

| **Metode poučevanja in učenja:** | **Learning and teaching methods:** |
|---|---|
| • Predavanja<br>• Seminarske vaje<br>• Izdelava seminarske naloge | • Lectures<br>• Tutorial<br>• Seminar (project) work |

**Načini ocenjevanja:** **Assessment:**

| Način (pisni izpit, ustno izpraševanje, naloge, projekt) | Delež (v %) / Weight (in %) | Type (examination, oral, coursework, project): |
|---|---|---|
| • Opravljena seminarska naloga | 10% | • Completed seminar (project) work |
| • Pisni izpit – problemi | 50% | • Written exam – problems |
| • Pisni izpit – teorija | 40% | • Written exam – theory |
| Pisni izpit – problemi se lahko nadomesti z dvema delnima testoma (sprotni obveznosti).<br>Pisni izpit – teorja se lahko nadomesti z dvema delnima testoma (sprotni obveznosti).<br>Vsaka izmed naštetih obveznosti mora biti opravljena s pozitivno oceno. | | Written exam – problems can be replaced by two parital tests (mid-term testing).<br>Written exam – theory can be replaced by two parital tests (mid-term testing).<br>Each of the mentioned commitments must be assessed with a passing grade. |

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

1. FERČEC, Brigita, ROMANOVSKI, Valery, TANG, Yilei, ZHANG, Ling. Integrability and bifurcation of a three-dimensional circuit differential system. *Discrete and continuous dynamical systems. Series B.* 2022, vol. 27, iss. 8, str. 4573-4588. ISSN 1531-3492. DOI: 10.3934/dcdsb.2021243. [COBISS.SI-ID 88277507]

2. 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]

3. WANG, Qinlong, YU'E, Xiong, HUANG, Wentao, ROMANOVSKI, Valery. Isolated periodic wave trains in a generalized Burgers–Huxley equation. *Electronic journal of qualitative theory of differential equations*. 2022, vol. 2022, no. 4, 16 str. ISSN 1417-3875. http://www.math.u-szeged.hu/ejqtde/p9524.pdf, DOI: 10.14232/ejqtde.2022.1.4. [COBISS.SI-ID 110159107]

4. 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]

5. LI, Yongjun, ROMANOVSKI, Valery. Isochronous solutions of a 3-dim symmetric quadratic system. *Applied mathematics and computation*. [Print ed.]. 15 Sept. 2021, vol. 405, 12 str. ISSN 0096-3003. DOI: 10.1016/j.amc.2021.126250. [COBISS.SI-ID 95936003]