



Univerza v Mariboru

Fakulteta za naravoslovje
in matematiko

UČNI NAČRT PREDMETA / COURSE SYLLABUS

Predmet:	Dinamični sistemi
Course title:	Dynamical Systems

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Fizika, 1. stopnja		3	5
Physics, 1st cycle		3	5

Vrsta predmeta / Course type

obvezni/compulsory

Univerzitetna koda predmeta / University course code:

Predavanja Lectures	Seminar Seminar	Sem. vaje Tutorial	Lab. vaje Lab. work	Druge oblike študija	Samost. delo Individ. work	ECTS
45			30		105	6

Nosilec predmeta / Lecturer:

Matjaž Perc

Jeziki /

Languages:

Predavanja /

Lectures:

slovensko / Slovenian

Vaje / Tutorial:

slovensko / Slovenian

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:

Ni pogojev za vključitev v delo.

Vsaka izmed naštetih obveznosti v načinih ocenjevanja mora biti opravljena s pozitivno oceno. Opravljene sprotne naloge so pogoj za pristop k ustnemu izpitu.

Prerequisites:

There are no prerequisites to join the course.

Each of the listed obligations in the assessment methods must be completed with a positive grade. Completed coursework is a prerequisite for taking the oral exam.

Vsebina:

Content (Syllabus outline):

1. Preprosti matematični opis dinamike sistema (enodimenzionalni (1D) sistemi) Splošna definicija dinamičnih sistemov, avtonomnost dinamičnega sistema, fazni prostor, linearna stabilnostna analiza, bifurkacijska analiza, enodimenzionalni sistemi in oscilacije. 2. Dinamični sistemi in oscilacije (2D sistemi) Linearni 2D sistemi, nelinearni 2D sistemi, linearizacija sistema in linearna stabilnostna analiza, konzervativni in disipativni sistemi, oscilator – konzervativni sistemi, oscilator – disipativni sistem, bifurkacije, bifurkacijski diagram, lokalne in globalne bifurkacije. 3. Kompleksni atraktorji (3D sistemi) Fourierjeva transformacija in avtokorelacija, Lyapunovi eksponenti, regularni atraktorji v 3D, kaos, čudni atraktorji in fraktalne dimenzije. 4. Aplikacije Pomen dinamičnih sistemov v fiziki in na drugih področjih: dinamični sistemi v biologiji, okoljevarstvu, ekonomiji, 5. Uporaba računalniških programov Uporaba računalniških programov za implementacijo dinamičnih sistemov: DynaSys, Stella, Madonna, C++, ...	1. Basic mathematical description of the system dynamics (one-dimensional (1D) systems) Definition of dynamical systems, autonomous dynamical systems, the phase space, the linear stability analysis, the bifurcation analysis, one-dimensional systems and oscillations. 2. Dynamical systems and oscillations (2D systems) Linear 2D systems, nonlinear 2D systems, linearization and linear stability analysis, conservative and dissipative systems, oscillator – conservative system, oscillator – dissipative system, bifurcations, bifurcation diagram, local and global bifurcations. 3. Complex attractors (3D systems) Fourier transformation and autocorrelation, Lyapunov exponents, regular attractors in 3D, chaos, strange attractors and fractal dimensions. 4. Applications The role of dynamical systems in physics and in other fields: dynamical systems in biology, environmental science, economy, ... 5. Using of computer programs Computer programmes for the implementation of dynamical systems: DynaSys, Stella, Madonna, C++, ...
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Temeljni literatura in viri / Readings:

- S. H. Strogatz, Nonlinear Dynamics and Chaos with Applications to Physics, Biology, Chemistry, and Engineering. Perseus Pub., Cambridge, 1994.
- H. Sayama, Introduction to the Modeling and Analysis of Complex Systems (State University of New York at Binghamton, Binghamton, NY, 2025); prosto dostopno: <https://open.umn.edu/opentextbooks/textbooks/introduction-to-the-modeling-and-analysis-of-complex-systems>
- N. Hritonenko, Y. Yatsenko, Mathematical Modeling in Economics, Ecology and the Environment, Springer, New York, 1999. Prosto dostopno: https://www.researchgate.net/publication/266015730_Mathematical_Modeling_in_Economics_Ecology_and_the_Environment

Dodatna literatura / Additional Readings

- J. B. Snape, I. J. Dunn, J. Ingham, J. E. Prenosil, Dynamics of Environmental Bioprocesses, Modelling and Simulation, VCH Verlagsgesellschaft, Weinheim, 1995. Strokovni in znanstveni članki v revijah / Articles published in professional and scientific journals.

Cilji in kompetence:

Razviti sposobnosti za opravljanje kvantitativne analize dinamike kompleksnih sistemov.

Razumeti ključne razlike in karakteristike dinamičnih sistemov v različnih dimenzijah.

Poznati uporabnost znanja o dinamičnih sistemih v naravnih sistemih in prenos znanja na druga področja.

Znati uporabiti računalniške programe za implementacijo dinamičnih sistemov.

Objectives and competences:

Develop the skills for quantitative analysis of the dynamics of complex systems.

Understand the basic differences and characteristics of dynamical systems in different dimensions.

Know the applicability of knowledge about dynamical systems in the nature and the transfer of knowledge to other fields.

Use computer programs for the implementation of dynamical systems.

Predvideni študijski rezultati:

Znanje in razumevanje:

Usvojiti metode za kvantitativno analizo dinamike kompleksnih sistemov.

Spoznati ključne razlike in karakteristike dinamičnih sistemov v različnih dimenzijah.

Spoznati uporabnost znanja o dinamičnih sistemih v fiziki in prenos znanja na druga področja.

Znati uporabljati računalniške programe za implementacijo dinamičnih sistemov.

Prenesljive/ključne spretnosti in drugi atributi:

Metode kvantitativne analize dinamičnih sistemov so univerzalne in jih je mogoče uporabiti na najrazličnejših področjih.

Poudarek je na prenosu znanja s primerov iz fizike na področja biologije, ekologije, ekonomije, ...

Intended learning outcomes:

Knowledge and understanding:

Be able to use methods for quantitative analysis of the dynamics of complex systems.

Know basic differences and characteristics of dynamical systems in different dimensions.

Be able to apply the knowledge about dynamical systems in physics to other fields.

Using computer programs for the implementation of dynamical systems.

Transferable/Key Skills and other attributes:

Methods for quantitative analysis of dynamical system are universal and can be implemented in different fields of research.

In particular, a knowledge transfer from examples in physics to examples in biology, ecology, economics, etc. is emphasised.

Metode poučevanja in učenja:

Predavanja

Vaje na računalniku

Learning and teaching methods:

Lectures

Computer exercises

Načini ocenjevanja:

Delež (v %) /

Weight (in %)

Assessment:

ustni izpit sprotne naloge	50 50	oral exam coursework
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Reference nosilca / Lecturer's references:

1. IZGI, Burhaneddin, ÖZKAYA, Murat, ÜRE, Nazim Kemal, PERC, Matjaž. A holistic matrix norm-based alternative solution method for Markov reward games. *Applied mathematics and computation*. [Print ed.]. Mar. 2025, vol. 488, [article no.] 129124, 13 str. ISSN 0096-3003. DOI: [10.1016/j.amc.2024.129124](https://doi.org/10.1016/j.amc.2024.129124). [COBISS.SI-ID [213539331](#)]
2. MAO, Shuai, MISHRA, Yateendra, TIAN, Yu-Chu, PERC, Matjaž, TANG, Yang. Distributed online optimization with edge-based event-triggered communication. *Automatica*. [Print ed.]. 2025, vol. 173, [article no.] 112068, 15 str. ISSN 0005-1098. DOI: [10.1016/j.automatica.2024.112068](https://doi.org/10.1016/j.automatica.2024.112068). [COBISS.SI-ID [221010691](#)]
3. BANERJEE, Ranjib, ACHARYA, Sayan, PERC, Matjaž, GHOSH, Dibakar. Anomalous complete synchronization in relay oscillators. *Chaos, solitons and fractals*. [Print ed.]. 2025, vol. 193, [article no.] 116069, 7 str. DOI: [10.1016/j.chaos.2025.116069](https://doi.org/10.1016/j.chaos.2025.116069). [COBISS.SI-ID [226119427](#)]
4. ZHANG, Yichao, WANG, Jiasheng, WEN, Guanghui, GUAN, Jihong, ZHOU, Shuigeng, CHEN, Guanrong, CHATTERJEE, Krishnendu, PERC, Matjaž. Limitation of time promotes cooperation in structured collaboration systems. *IEEE transactions on network science and engineering*. 2025, vol. 12, no. 1, str. 4-12. ISSN 2327-4697. DOI: [10.1109/TNSE.2024.3481434](https://doi.org/10.1109/TNSE.2024.3481434). [COBISS.SI-ID [221187331](#)]
5. ROY, Sourav, MAJHI, Soumen, PERC, Matjaž, GHOSH, Dibakar. Transitive to cyclic dominance in eco-evolutionary dynamics of strategic species. *Proceedings of the royal society A. Mathematical, Physical and Engineering Sciences*. [Online ed.]. Feb. 2025, vol. 481, iss. 2307, [article no.] 20240734, 24 str. ISSN 1471-2946. DOI: [10.1098/rspa.2024.0734](https://doi.org/10.1098/rspa.2024.0734). [COBISS.SI-ID [227067651](#)]
6. MARHL, Marko, MARKOVIČ, Rene, GRUBELNIK, Vladimir, PERC, Matjaž. The changing world dynamics of research performance. *Scientometrics*. 2025, vol. 130, str. 469-488. ISSN 1588-2861. DOI: [10.1007/s11192-024-05199-6](https://doi.org/10.1007/s11192-024-05199-6), DOI: [20.500.12556/DKUM-91828](https://doi.org/20.500.12556/DKUM-91828). [COBISS.SI-ID [225609219](#)]