



Univerza v Mariboru

Fakulteta za naravoslovje
in matematiko

UČNI NAČRT PREDMETA / COURSE SYLLABUS

Predmet:	Nelinearni dinamični sistemi
Course title:	Nonlinear Dynamical Systems

Študijski program in stopnja	Študijska smer	Letnik	Semester
Study programme and level	Study field	Academic year	Semester
Fizika 2. st.		1,2	1,2,3,4
Physics 2 nd degree			

Vrsta predmeta / Course type

izbirni / elective

Univerzitetna koda predmeta / University course code:

Predavanja Lectures	Seminar Seminar	Sem. vaje Tutorial	Lab. vaje Laboratory work	Teren. vaje Field work	Samost. delo Individ. work	ECTS
15		30			105	5

Nosilec predmeta / Lecturer:

Vladimir Grubelnik

Jeziki /

Predavanja / Lectures:

slovenski/Slovenian

Languages:

Vaje / Tutorial:

slovenski/Slovenian

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

Vsaka obveznost študenta v načinih ocenjevanja mora biti opravljena s pozitivno oceno. Opravljen projekt je pogoj za pristop k ustnemu izpitu.

Prerequisites:

Each student requirement within the assessment methods must be completed with a passing grade. Completed project is a prerequisite for taking the oral exam.

Vsebina:

Content (Syllabus outline):

1. Nelinearni dinamični sistemi v 1D, 2D in 3D Linearizacija in linearna stabilnostna analiza, bifurkacijska analiza. 2. Nelinearni oscilatorji Regularni oscilatorji kot konzervativni in disipativni sistemi (center, limitni cikel), bifurkacije, bifurkacijski diagram, lokalne in globalne bifurkacije. 3. Kvaziperiodičnost, kaos Fourierjeva transformacija in avtokorelacija, Lyapunovi eksponenti, kaos, fraktali in fraktalne dimenzije. 4. Enodimenzionalne preslikave 5. Stohastično modeliranje (Gillespiev algoritem) 6. Aplikacije Pomen dinamičnih sistemov v fiziki in na drugih področjih: dinamični sistemi v biologiji, okoljevarstvu, ekonomiji, 7. Uporaba računalniških programov Uporaba računalniških programov za implementacijo dinamičnih sistemov: Madonna, C++, Python.	1. Nonlinear dynamical systems (1D-, 2D-, 3D-systems) Linearization and the linear stability analysis, the bifurcation analysis. 2. Nonlinear oscillators Regular oscillators as conservative and dissipative systems (centre, limit cycle), bifurcations, bifurcation diagram, local and global bifurcations. 3. Quasiperiodicity, chaos Fourier transformation and autocorrelation, Lyapunov exponents, chaos, fractals and fractal dimensions. 4. Onedimensional mappings 5. Stochastic modelling (Gillespie's algorithm) 6. Applications The role of dynamical systems in physics and in other fields: dynamical systems in biology, environmental science, economy, ... 7. 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:

Steven H. Strogatz, Nonlinear Dynamics and Chaos with Applications to Physics, Biology, Chemistry, and Engineering. Perseus Pub., Cambridge, 1994.

Dodatna literatura / Additional Readings:

M. Lakshmanan, S. Rajasekar, Nonlinear Dynamics, Integrability, Chaos, and Patterns, Springer-Verlag Berlin Heidelberg, 2003.

J. B. Snape, I. J. Dunn, J. Ingham, J. E. Prenosil, Dynamics of Environmental Bioprocesses, Modelling and Simulation, VCH Verlagsgesellschaft, Weinheim, 1995.

Natali Hritonenko, Yuri Yatsenko, Mathematical Modeling in Economics, Ecology and the Environment, Springer, New York, 2013.

Strokovni in znanstveni članki v revijah / Articles published in professional and scientific journals.

Cilji:

- Študentje bodo znali kvantitativno analizirati dinamiko kompleksnih sistemov.
- Študentje bodo razumeli ključne razlike in karakteristike dinamičnih sistemov v različnih dimenzijah.
- Uporabiti znanje o dinamičnih sistemih v naravnih sistemih in drugih področjih.
- Uporaba računalniških programov za implementacijo dinamičnih sistemov.

Objectives:

- Students will be able to quantitative analyse the dynamics of complex systems.
- Students will be able to understand basic differences and characteristics of dynamical systems in different dimensions.
- Using knowledge about dynamical systems in the nature and the other fields.
- Using computer programs for the implementation of dynamical systems.

Predvideni študijski rezultati:**Znanje in razumevanje:**

- Uporabiti pridobljeno znanje pri kvantitativni analizi dinamike kompleksnih sistemov.
- Razložiti ključne razlike in karakteristike dinamičnih sistemov v različnih dimenzijah.
- Razumeti deterministično in stohastično modeliranje.
- Uporabiti znanje 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:**

- apply this knowledge at quantitative analysis of the dynamics of complex systems.
- explain the basic differences and characteristics of dynamical systems in different dimensions.
- Understand the deterministic and stochastic modelling.
- 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
- Teoretične vaje
- Vaje na računalniku
- Eksperimentalno delo

Learning and teaching methods:

- Lectures
- Theoretical exercises
- Computer exercises
- Experimental work

Načini ocenjevanja:

Delež (v %) /

Assessment:

Weight (in %)

• ustni izpit • projekt	50 50	• oral exam • project
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Reference nosilca / Lecturer's references:

1. GRUBELNIK, Vladimir, ZMAZEK, Jan, GOSAK, Marko, MARHL, Marko. The role of anaplerotic metabolism of glucose and glutamine in insulin secretion : a model approach. *Biophysical chemistry*. [Print ed.]. 2024, vol. 311, [article no.] 107270, 16 str., ilustr. ISSN 0301-4622. [COBISS.SI-ID [197803779](#)]
2. GRUBELNIK, Vladimir, ZMAZEK, Jan, ZAVRŠNIK, Matej, MARHL, Marko. Lipotoxicity in a vicious cycle of pancreatic beta cell exhaustion. *Biomedicines*. [Online ed.]. 2022, vol. 10, iss. 7, str. 1-16, ilustr. ISSN 2227-9059. <https://www.mdpi.com/2227-9059/10/7/1627>, DOI: 10.3390/biomedicines10071627. [COBISS.SI-ID 114930947]
3. ZMAZEK, Jan, GRUBELNIK, Vladimir, MARKOVIČ, Rene, MARHL, Marko. Modeling the amino acid effect on glucagon secretion from pancreatic alpha cells. *Metabolites*. 2022, vol. 12, iss. 4, str. 1-15, ilustr. ISSN 2218-1989. DOI: 10.3390/metabo12040348. [COBISS.SI-ID 105003779]