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
Dvopredmetna izobraževalna fizika	**/**	**2**	**3**
Double major Educational Physics	**/**		

Vrsta predmeta / Course type	Izbirni / Elective
Univerzitetna koda predmeta / University course code:	

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Lab. vaje Laboratory work	Terenske vaje Field work	Samost. delo Individ. work	ECTS
45			30		75	5

Nosilec predmeta / Lecturer:	Matjaž Perc

Jeziki / Languages:	**Predavanja / Lectures:**	slovenski / slovene
	Vaje / Tutorial:	slovenski / slovene

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Predznanje analize, algebre, matematične fizike.	Preknowledge of calculus, algebra and mathematical physics.

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, onedimensional 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++, …

Temeljni literatura in viri / Readings:

- Steven H. Strogatz, Nonlinear Dynamics and Chaos with Applications to Physics, Biology, Chemistry, and Engineering. Perseus Pub., Cambridge, 1994.
- 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, 1999.
- 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.

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.

Prenesljive/ključne spretnosti in drugi atributi:	Transferable/Key Skills and other attributes:
• 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, …	• 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:	Learning and teaching methods:
• Predavanja • Teoretične vaje • Vaje na računalniku	• Lectures • Theoretical exercises • Computer exercises

Načini ocenjevanja:	Delež (v %) / Weight (in %)	oral exam, seminar
- ustni izpit - seminarska naloga	70 30	- oral exam - seminar

Reference nosilca / Lecturer's references:

Detecting chaos from a time series, Stane Kodba, Matjaž Perc and Marko Marhl, Eur. J. Phys. 26, 205-215 (2005)
Visualizing the attraction of strange attractors, Matjaž Perc, Eur. J. Phys. 26, 579-587 (2005)
Nonlinear time series analysis of the human electrocardiogram, Matjaž Perc, Eur. J. Phys. 26, 757-768 (2005)
The dynamics of human gait, Matjaž Perc, Eur. J. Phys. 26, 525-534 (2005)
Deterministic chaos in sounds of Asian cicadas, Tina P. Benko and Matjaž Perc, J. Biol. Syst. 14, 555-566 (2006)
The dynamics of laser droplet generation, Blaž Krese, Matjaž Perc and Edvard Govekar, Chaos 20, 013129 (2010)