UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Dinamični sistemi v okolju
Course title:	Dynamical Systems in the Environment

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

Vrsta predmeta / Course type: izbirni/ optional

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
30	0	0	30	0	90	5

Nosilec predmeta / Lecturer: Marko Marhl

Jeziki / Languages:		
	Predavanja / Lectures:	Slovensko/Slovene
	Vaje / Tutorial:	Slovensko/Slovene

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Predznanje klasične in moderne fizike, sistemsko mišljenje in modeliranje sistemske dinamike.	Preknowledge of classical and modern Physics, system thinking and modelling of Systems dynamics

Vsebina:

1. Okoljski sistemi kot dinamični sistemi
   Osnove dinamičnih sistemov (linearna in nelinearnadinamika, stacionarna stanja sistema, stabilnostna analiza, bifurkacije, ….)

2. Kompleksnost modelov
   Oscilirajoči in neoscilirajoči sistemi. Kaotično obnašanje kompleksnih sistemov. Pri kaotičnih sistemih poudarimo občutljivost na začetne pogoje in pomen za okoljske sisteme.

3. Modeliranje kompleksnih okoljskih sistemov
   Modeliranje kroženja vode v naravi, padavine, površinske vode in regulacija nivoja podtalnice, modeliranje propagiranja polutantov v zraku in v vodi. Antropogeni dejavniki v okoljskih sistemih.

4. Računalniška simulacija in modelno napovedovanje
   Implementacija modelov v različnih okoljih: Madonna, C++, ….

Content (Syllabus outline):

1. Environmental systems – dynamical systems
   Basics about dynamical systems (linear and non-linear dynamics, steady states, stability analysis, bifurcations, ….)

2. Model complexity
   Oscillatory and non-oscillatory systems. Chaotic behaviour of complex systems. The extreme sensitivity of chaotic systems to initial conditions is pointed out for environmental systems.

3. Modelling of complex environmental systems
   Modelling of water-cycle, precipitations, surface water and regulation of the groundwater level, modelling of pollutants propagation in the air and water. Antropogen factors in environmental systems.

4. Computer simulation and model predictions
   Implementations of models in: Madonna, C++, …

Temeljni literatura in viri / Readings:

1. Steven H. Strogatz, Nonlinear Dynamics and Chaos with Applications to Physics, Biology, Chemistry, and Engineering. Perseus Pub., Cambridge, 1994.
2. Natali Hritonenko, Yuri Yatsenko, Mathematical Modeling in Economics, Ecology and the Environment, Springer, New York, 1999.
3. Gongbing Peng, Lance Leslie, Yaping Shao, Environmental Modeling and Prediction, Springer, New York, 2002.
4. Strokovni in znanstveni članki v revijah / Articles published in professional and scientific journals.

Cilji in kompetence:

- Predstaviti metode za kvalitativno analizo okoljskih sistemov.
- Razvijati sposobnosti za opravljanje kvantitativne analize okoljskih sistemov.
- Osnove matematičnega modeliranja.
- Poudariti univerzalnost metod in prenos znanja na druga področja.
- Uporaba računalniških programov za modeliranje sistemske dinamike.

Objectives and competences:

1. Presenting the methods for qualitative analysis of environmental systems.
2. Developing skills for quantitative analysis of environmental systems.
3. Basics of mathematical modelling.
4. Universality of the methods and transfer of knowledge to other fields.
5. Using computer programs for system dynamics modelling.

Predvideni študijski rezultati:

Znanje in razumevanje:

1. Usvojiti metode za kvalitativno analizo kompleksnih sistemov.
2. Sposobnost opravljanja kvantitativne analize kompleksnih sistemov.
3. Usvojiti osnove matematičnega modeliranja.
4. Znati uporabljati računalniške programe za modeliranje sistemske dinamike.

Prenesljive/ključne spretnosti in drugi atributi:

- Metode kvalitativne in kvantitativne analize dinamike sistemov so univerzalne in jih je mogoče uporabiti na najrazličnejših področjih.
- Poudarek je na prenosu znanja na druge sisteme ter povezavi predvsem okoljskih in ekonomski sistemov.

Intended learning outcomes:

Knowledge and Understanding:

1. Developing skills for qualitative analysis of complex systems.
2. Developing skills for quantitative analysis of complex systems.
3. Be able to construct basic mathematical models.
4. Be able to use computer programs for modelling system dynamics.

Transferable/Key Skills and other attributes:

- Methods for qualitative and quantitative analysis of system dynamics are universal and can be implemented in different fields of research.
- In particular, a knowledge transfer is emphasised to other fields and finding interconnections between environmental and economic systems.

Metode poučevanja in učenja:

- Predavanja
- Teoretične vaje
- Vaje na računalniku
- Eksperimentalne vaje

Learning and teaching methods:

1. Lectures
2. Theoretical exercises
3. Computer exercises
4. Experiments

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
ustni izpit	40	oral exam
pisni izpit	40	written exam
seminarska naloga	20	seminar

Reference nosilca / Lecturer's references:

BODENSTEIN, Christian, KNOKE, Beate, MARHL, Marko, PERC, Matjaž, SCHUSTER, Stefan. Using Jensen's inequality to explain the role of regular calcium oscillations in protein activation. *Physical biology*, 2010, vol. 7, no. 3, str. 036009-1-036009-12, doi: 10.1088/1478-3975/7/3/036009. [COBISS.SI-ID 14376470]

GOSAK, Marko, KOROŠAK, Dean, MARHL, Marko. Optimal network configuration for maximal coherence resonance in excitable systems. *Phys. rev., E Stat. nonlinear soft matter phys. (Print)*, 2010, vol. 81, iss. 5,

str. 056104-1-056104-7, ilustr., doi: 10.1103/PhysRevE.81.056104. [COBISS.SI-ID 17626120]

KNOKE, Beate, BODENSTEIN, Christian, MARHL, Marko, PERC, Matjaž, SCHUSTER, Stefan. Jensen's inequality as a tool for explaining the effect of oscillations on the average cytosolic calcium concentration.*Theory biosci.*, Jun. 2010, vol. 129, no. 1, str. 25-38, doi: 10.1007/s12064-010-0080-1. [COBISS.SI-ID 14376726]

GOSAK, Marko, KOROŠAK, Dean, MARHL, Marko. Topologically determined optimal stochastic resonance responses of spatially embedded networks. *New journal of physics*. [Online ed.], Jan. 2011, vol. 13, issue 1, str. 013012-1-013012-15, ilustr. http://dx.doi.org/10.1088/1367-2630/13/1/013012. [COBISS.SI-ID 18087432]

GOSAK, Marko, MARKOVIČ, Rene, MARHL, Marko. The role of neural architecture and the speed of signal propagation in the process of synchronization of bursting neurons. *Physica, A*. [Print ed.], 2012, vol. 391, no. 8, str. 2764-2770, ilustr., doi: 10.1016/j.physa.2011.12.027. [COBISS.SI-ID 18948872]