Univerza v Mariboru

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Fakulteta za naravoslovje in matematiko

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	**Modeliranje sistemov v okolju**
Course title:	Modelling of Environmental Systems

Študijski program in stopnja Study programme and level	**Študijska smer Study field**	**Letnik Academic year**	**Semester Semester**
Biologija in ekologija z naravovarstvom, 2. stopnja	**/**	**1/2**	**Poletni/ Zimski**
Biology and Ecology with Nature Conservation, 2nd Level	**/**	**1/2**	**Summer/ Winter**

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	**15**		**15**		**135**	**6**

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:**

Vsebina:

- Okoljski sistemi: struktura, dinamika in razvoj sistemov
- Analiza sistemov
- Kvalitativna analiza sistemov
  - Določitev sistema in njegove okolice, ki pomembno vpliva na dinamiko sistema. Razgradnja sistema; prepoznavanje komponent sistema, določitev povezav med deli sistema, medsebojnih vplivov in zunanjih vplivov na sistem.
  - Kvantitativna analiza dinamike sistemov Določanje spremenljivk v sistemu, ki opisujejo stanja in tokove. Medsebojni vplivi in zunanji vplivi na posamezne spremenljivke.
- Opis dinamike sistemov
  - Kvalitativni opis dinamike sistemov: diagrami stanj in tokov, kavzalni diagrami.
  - Kvantitativni opis sistemske dinamike: prehod s kavzalnih diagramov in diagramov stanj in tokov na matematičen opis vpliva tokov količin na njihovo dinamiko; diferenčne enačbe; matematični model.
- Modeliranje, simulacija, napovedi modelov
- Konstruiranje preprostih modelov: populacijski modeli, modeli ekosistemov, kroženje snovi v naravi, modeli na celični ravni, … Reševanje diferenčnih enačb v urejevalnikih tabel (Excel) – simulacija s poudarkom na napovedni moči modelov.

- Uporaba računalniških programov
  Grafično orientirani računalniški programi za modeliranje sistemske dinamike: DynaSys, Stella, Vensim, Powersim, Madonna, ….

Content (Syllabus outline):

- Environmental systems: structure, dynamics and system's development
- Systems analysis
- Qualitative system analysis:
  - Determination of a system and its surrounding that considerably influences the systems dynamics. Decomposition of a system into components, determining the interrelations between the components, influences between the components and external influences on the system.
  - Quantitative analysis of system dynamics: Determination of system variables – the so-called stock and flow variables. Interrelated influences and external influences on the variables.
- Description of system dynamics
  - Qualitative approaches in system dynamics: causal-loop diagrams, stock-flow diagrams.
  - Quantitative approaches in system dynamics: quantification of causal-loop diagrams and stock-flow diagrams; mathematical description of influences of fluxes on system variables; mathematical model.
- Modelling, simulation, model prediction
- Construction of simple models: models of population dynamics, ecosystems, models on cellular level, …. Solving of equations in spread-sheet programmes (Excel) – simulations with emphasis on predictive power of models.

- Using computer programs

- Graphic-oriented computer programmes for modelling of system dynamics: DynaSys, Stella, Vensim, Powersim, Madonna, ….

Temeljni literatura in viri / Readings:

S. P. Otto, S.A. & T. Day, A Biologist's Guide to Mathematical Modeling in Ecology and Evolution, Princeton University Press, 2007.

D. H. Meadows, D.H. Thinking in Systems, Chelsa Green Publishing, 2008.

S. H. Strogatz, Nonlinear Dynamics And Chaos: With Applications To Physics, Biology, Chemistry, And Engineering, Westview Press, 2000.

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

Cilji in kompetence:

Objectives and competences:

• Ponazoriti zvezo med strukturo, dinamiko in razvojem okoljskih sistemov • Predstaviti odnos med sistemskim mišljenjem in modeliranjem sistemske dinamike • Obdelati celovito kvalitativno in kvantitativno analizo dinamike okoljskih sistemov • Prenos uporabe univerzalnih metod analize na druga področja • 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 bioloških sistemov	• Presenting the relationship between the structure, dynamics, and development of environmental systems • Establishing the relationship between the system thinking and system dynamics modelling • Working on a complete qualitative and quantitative analysis of system dynamics • Transfer of using general methods of the analysis to other fields • 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 biological systems

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: • Poznati zvezo med strukturo, dinamiko in razvojem okoljskih sistemov • Poznati odnos med sistemskim mišljenjem in modeliranjem sistemske dinamike • Obvladati kvalitativno in kvantitativno analizo dinamike okoljskih sistemov na enostavnih primerih • Znati uporabljati grafično orientirane računalniške programe za modeliranje in simulacijo dinamike sistemov	Knowledge and understanding: • Know the relationship between the structure, dynamics, and development of environmental systems • Know the relationship between the system thinking and system dynamics modelling • Be able to carry out a complete qualitative and quantitative analysis of system dynamics for simple systems • Be able to use graphic-oriented computer programmes for modelling and simulation of dynamical systems

Metode poučevanja in učenja:	**Learning and teaching methods:**
• Predavanja • Seminar • Vaje na računalniku	• Lectures • Seminar • Computer exercises

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt) • Seminarska naloga • Pisni izpit	50 50	Type (examination, oral, coursework, project): • Seminar essay • Written exam

Reference nosilca / Lecturer's references:

- BODENSTEIN, Christian, GOSAK, Marko, SCHUSTER, Stefan, MARHL, Marko, PERC, Matjaž. Modeling the seasonal adaptation of circadian clocks by changes in the network structure of the suprachiasmatic nucleus. *PLOS comput. biol.*, Sep. 2012, vol. 8, iss. 9, e1002697-1-e1002697-12, doi: 10.1371/journal.pcbi.1002697. [COBISS.SI-ID 19375368]
- 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]
- MARHL, Marko, GOSAK, Marko, PERC, Matjaž, ROUX, Etienne. Importance of cell variability for calcium signaling in rat airway myocytes. *Biophysical chemistry*. [Print ed.], 2010, vol. 148, iss. 1/3, str. 42-50, doi: 10.1016/j.bpc.2010.02.006. [COBISS.SI-ID 14070550]
- 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]
- MARHL, Marko, GOSAK, Marko, PERC, Matjaž, DIXON, C. Jane, GREEN, Anne K. Spatio-temporal modelling explains the effect of reduced plasma membrane Ca[sup]2+ efflux on intracellular Ca[sup]2+ oscillations in hepatocytes. *J. theor. biol.*, 2008, vol. 252, iss. 3, str. 419-426, doi: 10.1016/j.jtbi.2007.11.006.