Univerza v Mariboru

Fakulteta za naravoslovje in matematiko

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	**Izbrana poglavja iz modeliranja sistemov v okolju**
Course title:	**Selected Topics in Modelling of Environmental Systems**

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Doktorski študij Ekološke znanosti, 3. stopnja		**1. 1. ali 2.; 1st or 2nd**	**1. 2. ali 3. ; 1st, 2nd or 3rd**
Doctoral Study Ecological Sciences, 3rd degree			

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
5		5			140	5

Nosilec predmeta / Lecturer:	Marko MARHL

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

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Znanje fizike, matematike in računalništva na dodiplomski ravni.	Knowledge of physics, mathematics and computer science at undergraduate level

Vsebina:	**Content (Syllabus outline):**

Obravnavana so izbrana poglavja iz naslednjih sklopov.
 	
• 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
	Selected topics in the following chapters are discussed.
	
	• 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,

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, ….	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:

- Gharajedaghi, J., 2011: Systems Thinking: Managing Chaos and Complexity, 3rd Ed., Elsevier, Amsterdam.
- Meadows, D. H., 2008: Thinking in Systems, Chelsea Green Publishing, White River Junction, Vermont.
- Ford, A., 1999: Modeling the Environment; An Introduction to System Dynamics Modeling of Environmental Systems, Island Press.
- Hritonenko, N., Y. Yatsenko, 1999: Mathematical Modeling in Economics, Ecology and the Environment, Springer, New York.
- Jørgensen, S. E., B. Halling-Sørensen, S.N. Nielsen, 1996: Handbook of Environmental and Ecological Modeling, CRC PressLLC.
- Ossimitz, G., 2000: Entwicklung systemischen Denkens, Theoretische Konzepte und empirische Untersuchungen, Profil Verlag, München.
- Strokovni in znanstveni članki v revijah / Articles published in professional and scientific journals.

Cilji in kompetence:	**Objectives and competences:**
• Podrobno ponazoriti zvezo med strukturo, dinamiko in razvojem okoljskih sistemov • Podrobno predstaviti odnos med sistemskim mišljenjem in modeliranjem sistemske dinamike • Opraviti podrobno celovito kvalitativno in kvantitativno analizo dinamike okoljskih sistemov • Prenos uporabe univerzalnih metod analize na druga področja	• Presenting the relationship between the structure, dynamics, and development of environmental systems in detail • Establishing the relationship between the system thinking and system dynamics modelling in detail • Carrying out a advanced complete qualitative and quantitative analysis of system dynamics • Transfer of using general methods of the analysis to other fields

Predvideni študijski rezultati:	Intended learning outcomes:
Znanje in razumevanje: • Poznati zvezo med strukturo, dinamiko in razvojem okoljskih sistemov v podrobnostih • Podrobno poznati odnos med sistemskim mišljenjem in modeliranjem sistemske dinamike • Podrobno obvladati kvalitativno in kvantitativno analizo dinamike okoljskih sistemov na enostavnih primerih • Znati podrobno uporabljati grafično orientirane računalniške programe za modeliranje in simulacijo dinamike sistemov **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 podrobnega znanja na druge sisteme ter povezavi predvsem okoljskih in bioloških sistemov	**Knowledge and understanding:** • Know the relationship between the structure, dynamics, and development of environmental systems in detail • Know in detail 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 in detail • Be able to use graphic-oriented computer programmes for modelling and simulation of dynamical systems in detail. **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 advanced knowledge transfer is emphasised to other fields and finding interconnections between environmental and biological systems

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 %)	Assessment:
• Seminarska naloga • Ustni izpit	40 % 60 %	• Seminar essay • Oral exam

Reference nosilca / Lecturer's references:

- FORJAN, Matej, MARHL, Marko, GRUBELNIK, Vladimir. Mathematical modelling of the electrostatic pendulum in school and undergraduate education. *European journal of physics*, ISSN 0143-0807, 2014, vol. 35, no. 1, str. 015022-1-015022-13, doi: 10.1088/0143-0807/35/1/015022. [COBISS.SI-ID 20357128], [JCR, SNIP, WoS do 24. 2. 2014: št. citatov (TC): 0, čistih citatov (CI): 0, normirano št. čistih citatov (NC): 0, Scopus do 22. 10. 2014: št. citatov (TC): 1, čistih citatov (CI): 1, normirano št. čistih citatov (NC): 1]

- 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 computational biology*, ISSN 1553-734X, Sep. 2012, vol. 8, iss. 9, e1002697-1-e1002697-12, doi: 10.1371/journal.pcbi.1002697. [COBISS.SI-ID 19375368], [JCR, SNIP, WoS do 11. 12. 2013: št. citatov (TC): 3, čistih citatov (CI): 3, normirano št. čistih citatov (NC): 2, Scopus do 8. 1. 2014: št. citatov (TC): 4, čistih citatov (CI): 4, normirano št. čistih citatov (NC): 2]

- GOSAK, Marko, KOROŠAK, Dean, MARHL, Marko. Topologically determined optimal stochastic

resonance responses of spatially embedded networks. *New journal of physics*, ISSN 1367-2630. [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], [JCR, SNIP, WoS do 22. 4. 2014: št. citatov (TC): 4, čistih citatov (CI): 1, normirano št. čistih citatov (NC): 0, Scopus do 30. 4. 2014: št. citatov (TC): 4, čistih citatov (CI): 1, normirano št. čistih citatov (NC): 0]

- GRUBELNIK, Vladimir, DUGONIK, Bogdan, OSEBIK, Davorin, MARHL, Marko. Signal amplification in biological and electrical engineering systems : universal role of cascades. *Biophysical chemistry*, ISSN 0301-4622. [Print ed.], aug. 2009, vol. 143, iss. 3, str. 132-138, ilustr. [COBISS.SI-ID 17043720], [JCR, SNIP, WoS do 19. 5. 2014: št. citatov (TC): 8, čistih citatov (CI): 8, normirano št. čistih citatov (NC): 3, Scopus do 10. 12. 2013: št. citatov (TC): 9, čistih citatov (CI): 9, normirano št. čistih citatov (NC): 3]

- 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. *Journal of theoretical biology*, ISSN 0022-5193, 2008, vol. 252, iss. 3, str. 419-426, doi: 10.1016/j.jtbi.2007.11.006. [COBISS.SI-ID 16014344], [JCR, SNIP, WoS do 14. 7. 2014: št. citatov (TC): 10, čistih citatov (CI): 10, normirano št. čistih citatov (NC): 5, Scopus do 28. 7. 2014: št. citatov (TC): 10, čistih citatov (CI): 10, normirano št. čistih citatov (NC): 5]