Univerza v Mariboru

Fakulteta za naravoslovje in matematiko

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Sistemsko mišljenje
Course title:	System Thinking

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Fizika		**1**	**1**
Physics			

Vrsta predmeta / Course type

Univerzitetna koda predmeta / University course code:

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike študija	Samost. delo Individ. work	ECTS
45		**30**			**105**	**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:**
Pogojev ni.	None.

Vsebina:	**Content (Syllabus outline):**
1. Struktura, dinamika in evolucija kompleksnih sistemov v naravi, tehniki in družbi. 2. Sistemsko mišljenje in modeliranje sistemske dinamike. 3. Analiza kompleksnega sistema: določitev sistema in njegove okolice, ki ima vpliv na dinamiko sistema (primeri iz fizike; npr. mehanike – izbor sistema in določitev njegove okolice). Razgradnja kompleksnega sistema; prepoznavanje komponent	1. Structure, dynamics and evolution of natural, technical and social complex system. 2. System Thinking and System Dynamics Modelling. 3. Analysis of complex system: system determination and taking into account the surrounding that influences the system (examples in Physics, e.g., mechanics – system determination and its surrounding). Decomposition of complex system into components, determining the interrelations between

sistema, določitev povezav med deli sistema, medsebojnih vplivov in zunanjih vplivov na sistem. 4. Kvalitativni opis sistemske dinamike: kavzalni diagrami in diagrami stanj in tokov. 5. Aplikacije v fiziki in na drugih področjih: populacijska dinamika, okoljevarstvo, dinamika bioloških sistemov, ...	the components, influences between the components and external influences on the system. 4. Qualitative approaches in system dynamics: causal loop diagrams, stock-flow diagrams. 5. Applications in Physics and in other fields: population dynamics, environmental systems, biological systems, ...

Temeljni literatura in viri / Readings:

- J. W. Forrester, World Dynamics, Wright-Allen Press, Cambridge 1971.
- G. Ossimitz, Entwicklung systemischen Denkens, Theoretische Konzepte und empirische Untersuchungen, Profil Verlag, München 2000.
- P.M. Senge, The Fifth Discipline: The Art and Practice of the Learning Organisation. Doubleday, New York 1990.
- P.M. Senge, N. Cambron-McCabe, T. Lucas, B. Smith, J. Dutton, A. Kleiner, Schools that Leatn: A Fifth Discipline Fieldbook for Educators, Parents, and Everyone Who Cares About Education. Doubleday, New York 2000.
- Strokovni in znanstveni članki v revijah / Articles published in professional and scientific journals.

Cilji in kompetence:	**Objectives and competences:**
Cilj tega predmeta je, da bodo študenti razumeli osnove delovanja in kompleksnosti sistemov. Operativni cilji so: • ponazoriti zvezo med strukturo, dinamiko in evolucijo kompleksnih sistemov; • predstaviti odnos med sistemskim mišljenjem in modeliranjem sistemske dinamike; • obdelati celotno kvalitativno analizo dinamike kompleksnih sistemov na enostavnih fizikalnih primerih; • prenos uporabe univerzalnih metod analize s fizikalnih primerov na področja populacijske dinamike, okoljevarstva, bioloških sistemov, ...	The objective of this course is for students to be able to understand the basics of functioning and complexity of systems. The operative objectives are: • presenting the relationship between the structure, dynamics, and evolution of complex systems; • establishing the relationship between the system thinking and system dynamics modelling; • carrying out the qualitative analysis of system dynamics for simple physical systems; • transfer of using general methods for the analysis of physical systems to other fields, e.g., population dynamics, environment, biological systems, ...

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: Po uspešnem zaključku tega predmeta bo študent zmožen:	**Knowledge and understanding:** On completion of this course the student will be able to:

• definirati strukturo, dinamiko in evolucijo izbranega kompleksnega sistema; • razložiti strukturo sistema kot posledico sistemske dinamike; • zapisati ključne tokove fizikalnih količin, ki opisujejo dinamiko sistema; • zapisati energijske tokove, ki spremljajo osnovne tokove ekstenzivnih količin; • uporabiti metode za kvalitativno analizo dinamike kompleksnih sistemov na enostavnih fizikalnih primerih. **Prenesljive/ključne spretnosti in drugi atributi:** Po uspešnem zaključku tega predmeta bo študent zmožen: • boljšega komuniciranja na področju naravoslovja; • uporabljati nove informacijske tehnologije: uporaba računalniških programov za modeliranje sistemov; • učinkovitega reševanja problemov: reševanje problemov z uporabo modeliranja dinamike sistemov; • prenesti znanja s primerov iz fizike na področja populacijske dinamike, okoljskih problemov, bioloških sistemov, …	• define the structure, dynamics, and evolution of a given complex system; • explain the structure of a system as a consequence of the system dynamics; • define the key fluxes of physical quantities that are part of the system dynamics; • define the energy fluxes related to the basal fluxes of the extensive quantities; • implement methods for qualitative analysis of system dynamics for simple physical systems. **Transferable/Key Skills and other attributes:** On completion of this course the student will be able to: • better communicate in the field of natural sciences; • use modern information technology; in particular, use of computer programs for systems modelling. • effectively solve problems: problem solving with the modelling of systems dynamics. • transfer of knowledge from the examples in physics to other fields, e.g., population dynamics, environment, biological systems, …

Metode poučevanja in učenja:	**Learning and teaching methods:**
• Predavanja • Teoretične vaje • Vaje na računalniku • Eksperimentalne vaje	• Lectures • Theoretical exercises • Computer exercises • Experiments

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt): • ustni izpit • pisni izpit • seminarska naloga Za uspešno zaključeno učno enoto mora biti vsak del posebej pozitiven. Opravljena seminarska naloga je pogoj za pristop k pisnemu izpitu.	**40** **40** **20**	Type (examination, oral, coursework, project): • oral • written • seminar work For a successfully finished course, all parts have to be positive.

		A passing grade of the seminar work is a prerequisite to access the oral and written exam.

Reference nosilca / Lecturer's references:

GOSAK, Marko, MARKOVIČ, Rene, DOLENŠEK, Jurij, RUPNIK, Marjan, MARHL, Marko, STOŽER, Andraž, PERC, Matjaž. Network science of biological systems at different scales : a review. *Physics of life reviews*, ISSN 1873-1457, 2018, vol. 24, str. 118-135, doi: 10.1016/j.plrev.2017.11.003. [COBISS.SI-ID 512746040], [JCR, SNIP, WoS do 9. 6. 2019: št. citatov (TC): 42, čistih citatov (CI): 39, Scopus do 29. 5. 2019: št. citatov (TC): 57, čistih citatov (CI): 52]

MARKOVIČ, Rene, GOSAK, Marko, GRUBELNIK, Vladimir, MARHL, Marko, VIRTIČ, Peter. Data-driven classification of residential energy consumption patterns by means of functional connectivity networks. *Applied energy*, ISSN 0306-2619, 2019, vol. 242, str. 506-515, graf. prikazi, doi: 10.1016/j.apenergy.2019.03.134. [COBISS.SI-ID 1024346460], [JCR, SNIP, Scopus do 29. 4. 2019: št. citatov (TC): 1, čistih citatov (CI): 1]

MARKOVIČ, Rene, PELTAN, Julien, GOSAK, Marko, HORVAT, Denis, ŽALIK, Borut, SEGUY, Benjamin, CHAUVEL, Remi, MALANDAIN, Gregoire, COUFFINHAL, Thierry, DUPLÁA, Cécile, MARHL, Marko, ROUX, Etienne. Planar cell polarity genes frizzled4 and frizzled6 exert patterning influence on arterial vessel morphogenesis. *PloS one*, ISSN 1932-6203, 2017, vol. 12, iss. 3, str. 1-19, doi: 10.1371/journal.pone.0171033. [COBISS.SI-ID 22990856], [JCR, SNIP, WoS do 12. 5. 2019: št. citatov (TC): 3, čistih citatov (CI): 2, Scopus do 29. 5. 2019: št. citatov (TC): 3, čistih citatov (CI): 2]

ROUX, Etienne, MARHL, Marko. Theoretical analysis of the vascular system and its relation to Adrian Bejan's constructal theory. *Journal of Theoretical and Applied Vascular Research*, ISSN 2532-0831, Feb. 2017, vol. 2, iss. 1, str. 1-6, doi: 10.24019/jtavr.20. [COBISS.SI-ID 24300552]

GOSAK, Marko, STOŽER, Andraž, MARKOVIČ, Rene, DOLENŠEK, Jurij, PERC, Matjaž, RUPNIK, Marjan, MARHL, Marko. Critical and supercritical spatiotemporal calcium dynamics in beta cells. *Frontiers in physiology*, ISSN 1664-042X, 2017, vol. 8, str. 1-17, ilustr., doi: 10.3389/fphys.2017.01106. [COBISS.SI-ID 512760376], [JCR, SNIP, WoS do 12. 5. 2019: št. citatov (TC): 5, čistih citatov (CI): 4, Scopus do 29. 5. 2019: št. citatov (TC): 6, čistih citatov (CI): 5]