UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Modeliranje kompleksnih sistemov
Course title:	Modeling complex systems

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Podatkovne znanosti, magistrski študijski program druge stopnje	-	Prvi	Drugi
The second cycle masters study programme Data Sciences	-	First	Second

Vrsta predmeta / Course type	Izbirni / elective
Univerzitetna koda predmeta / University course code:	2-PZ-MAG-IP-MKS-2020-06-30

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **work**	**Druge oblike študija**	**Samost. delo** **Individ. work**	**ECTS**
30	-	30	-	-	90	5

Nosilec predmeta / Lecturer:	Izr. prof. dr. Zoran Levnajić

Jeziki / Languages:	**Predavanja / Lectures:**	Slovenščina/English
	Vaje / Tutorial:	Slovenščina/English

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**

Za vključitev v delo mora študent poznati osnovne principe programiranja (v poljubnem programskem jeziku). Zahteva se tudi poznavanje osnov matematike in statistike.	Students need basic familiarity with computer programming (in any programming language). Also they need solid background in undergraduate mathematics and statistics.

Vsebina:	**Content (Syllabus outline):**
Uvod v kompleksne sisteme • Kaj je kompleksnost in zakaj jo študirati? • Kompleksno vs. komplicirano • Osnovni primeri, zapornikova dilema Koncepti modeliranja • Kaj je model? Zakaj modeliramo? • Tipi modelov in njihov namen • Kako razviti elementaren model? • Modeliranje pojavov na različnih ravneh Kompleksnosti sistemi v realnem svetu • Samo-organiziranje v naravi in družbi • Družba kot kompleksen sistem • Finance kot kompleksen sistem • Primeri iz naravoslovnih znanosti • Primeri iz tehnologije in infrastrukture • Drugi zanimivi primeri Dinamični modeli kompleksnih sistemov • Conwayeva igra življenja, celični avtomati • Modeli tipa plenilec-plen • Modeliranje širitev in okužb • Modeli ustvarjanja mnenj • Modeli v teoriji iger, sodelovanje Omrežja kot modeli kompleksnih sistemov • Model Erdős-Renyi • Model Watts-Strogatz • Model Barabasi-Albert • Konfiguracijski modeli • Drugi modeli Modeliranje kompleksnih sistemov z agenti • Posamezne enote/agenti in njihovi atributi • Dinamika in interakcije med agenti • Raznolikost pojavov za modeliranje z agenti	Introduction to complex systems • what is complexity and why study it? • complex vs. complicated • basic examples, prisoner's dilemma The concept of modeling • what is a model? why we model? • types of models and their purposes • how to develop an elementary model? • modeling phenomena at different levels Real-world complex systems • self-organizaton in nature and society • society as a complex system • financies as a complex system • examples from natural sciences • examples from technology and infrastructure • other interesting examples Dynamical models of complex systems • Conway's game of life, cellular automata • predator-prey models • spreading processes and contagions • opinion formation models • game theory models, cooperative behavior Networks as models of complex systems • Erdős-Renyi model • Watts-Strogatz model • Barabasi-Albert model • configuration models • other models Agent-based models of complex systems • individual units/agents and their attributes • dynamics and interactions among agents

• Šum in stohastično obnašanje	• diversity of phenomena to model via agents • noise and stochastic behavior

Temeljni literatura in viri / Readings:

- SPage, Scott: Model thinking, online course at University of Michigan https://www.coursera.org/learn/model-thinking
- Barabási, Albert-László (2016): Network Science. Cambridge University Press, cop. Dostopno prek: http://networksciencebook.com/
- Easley, David and Kleinberg, Jon (2010): Networks, Crowds, and Markets, Cambridge University Press. Dostopno prek: https://www.cs.cornell.edu/home/kleinber/networks-book/
- Levnajić, Zoran: Prosojnice iz predavanj pri predmetu Modeliranje kompleksnih sistemov. Moodle, FIŠ.

Cilji in kompetence:	**Objectives and competences:**
Splošne kompetence • Uporaba ustreznih metodoloških pristopov za izvajanje, koordiniranje in organiziranje raziskav. • Sposobnost obvladovanja in pretvorbe realnega problema v obliki lažje predstavljivega modela. • Sposobnost analitičnega in algoritmičnega razmišljanja. **Predmetno-specifične kompetence:** • Poznavanje teorije kompleksnih sistemov • Sposobnost modeliranja na različnih ravneh natančnosti	**General competences** • Utilization of adequate methodological approaches to conduct, coordination and organisation of research. • The ability to manage and transform a real problem into a simplified model. • The ability of analytical and algorithmic thinking. **Subject-specific competences:** • expertise in theory of complex systems

• Matematično in računsko modeliranje • Sposobnost simuliranja kompleksnih sistemov na računalniku	• ability to design models at various levels of sophisitication • mathematical and computational modeling • ability to simulate complex systems on a computer

Predvideni študijski rezultati:	**Intended learning outcomes:**
Po uspešno opravljenem predmetu, bo študent imel: • dobro razumevanje kompleksnosti v naravi in družbi, • dobro razumevanje ideje in namena modeliranja, • znanje o osnovnih in (nekaterih) naprednih tehnikah modeliranja • spretnosti pri razvoju in analizi osnovnih modelov od začetka.	Upon successfully completing this course a student will have: • good understanding of complexity in nature and society • good understanding of the idea and purpose of modeling • knowledge of basic and (some) advanced modeling techniques • skills in developing and analyzing basic models »from scratch«

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja z aktivno udeležbo študentov. Praktične vaje, kjer študentje uporabljajo metode naučene na predavanjih in razvijajo preproste programe.	Lectures with active participation of students. Practical hands-on exercises, where students use methods learnt at lectures and develop elementary programming codes themselves.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt) • domače naloge, kjer študentje rešijo zaokroženo celoto nalog (večinoma v obliki pisanja programske kode) • vsak študent individualno pripravi zaključni projekt	50 % 50 %	Type (examination, oral, coursework, project): • homeworks where students complete sets of exercises (mostly writing programming codes). • each student shall have his/her individual final project

Reference nosilca / Lecturer's references:

- K. Ban, M. Perc, Z. Levnajić, Robust clustering of languages across Wikipedia growth, Journal of the Royal Society Open Science 4, 171217, 2017.
- I. Tokuda, Z. Levnajić, K. Ishimura, A practical method for estimating coupling functions in complex dynamical systems, Philosophical Transactions of the Royal Society A 377, 20190015, 2019.
- A. Zorko, M. Frühwirth, N. Goswami, M. Moser, Z. Levnajić, Heart Rhythm Analyzed via Shapelets Distinguishes Sleep From Awake, Frontiers in Physiology 10, 1554, 2020.
- M. Grau Leguia, Z. Levnajić, L. Todorovski, B. Ženko, Reconstructing dynamical networks via feature ranking, Chaos 29, 093107, 2019.
- A. Guazzini, F. Stefanelli, E. Imbimbo, D. Vilone, F. Bagnoli, Z. Levnajić, Humans best judge how much to cooperate when facing hard problems in large groups, Scientific Reports 9, 5497, 2019.