UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	**Modeliranje sistemske dinamike**
Course title:	**System Dynamics Modelling**

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Enovit magistrski študijski program druge stopnje Predmetni učitelj	/	3	6
Five-year master's degree program Subject Teacher	/		

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
45			30		135	7

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:**
predznanje pridobljeno pri predmetu sistemsko mišljenje in osnove klasične fizike.	Preknowledge of system thinking and the basic knowledge of classical physics.

Vsebina:	**Content (Syllabus outline):**
1. Kvalitativna analiza kompleksnih sistemov. 2. Kvantitativna analiza dinamike kompleksnih sistemov: določanje spremenljivk v sistemu, ki opisujejo stanja in tokove. Medsebojni vplivi in zunanji vplivi na posamezne spremenljivke.	1. Qualitative analysis of complex systems. 2. Quantitative analysis of the dynamics of complex systems: determination of system variables – the socalled stock and flow variables. Interrelated influences and external influences on the variables. 3. Quantitative modelling of system dynamics;

3. Kvantitativni opis modela sistemske dinamike; prehod s kavzalnih diagramov in diagramov stanj in tokov na matematičen opis vpliva tokov količin na njihovo dinamiko; diferenčne enačbe 4. Konstruiranje matematičnih modelov v fiziki; prikaz prednosti modelnega pristopa; primeri, ki so analitično težko rešljivi: npr. upoštevanje zračnega upora v primerih iz kinematike, …; primeri, ki nakazujejo univerzalnost pristopov: npr. modeliranje radioaktivnih razpadov, …. 5. Aplikacije v fiziki in na drugih področjih: modeli populacijske dinamike, biološki sistemi, … 6. Uporaba računalniških programov za modeliranje sistemske dinamike: grafično orientirani programi DynaSys, Stella, Madonna, …; primerjava z Excel, C++.	quantification of causal-loop diagrams and stock-flow diagrams; mathematical description of influences of fluxes on system variables; model equations. 4. Construction of mathematical models in Physics; pointing out the advantages of the modelling approach; examples of analytically difficult-solvable problems: kinematics with air resistance, …; examples of generalisation of approaches: e.g. modelling of radioactive decay, … 5. Applications in Physics and other fields: modelling of population dynamics, biological systems, … 6. Using computer programs for modelling of system dynamics: graphic-oriented computer programmes: DynaSys, Stella, Madonna, …; comparison with Excel, C++.

Temeljni literatura in viri / Readings:

- J. W. Forrester, World Dynamics, Wright-Allen Press, Cambridge 1971.
- H. P. Schecker, Physik-Modellieren, Grafikorientierte Modellbildungssysteme im Physikunterricht, Ernst Klett Verlag, Stuttgart (1998).
- J. B. Snape, I. J. Dunn, J. Ingham, J. E. Prenosil, Dynamics of Environmental Bioprocesses, Modelling and Simulation, VCH Verlagsgesellschaft, Weinheim 1995.
- Strokovni in znanstveni članki v revijah / Articles published in professional and scientific journal

Cilji in kompetence:	**Objectives and competences:**
Predstaviti metode za kvalitativno analizo kompleksnih sistemov. Razvijati sposobnosti za opravljanje kvantitativne analize kompleksnih sistemov. Osnove matematičnega modeliranja. Poudariti univerzalnost metod in prenos znanja na druga področja. Uporaba računalniških programov za modeliranje sistemske dinamik	Presenting the methods for qualitative analysis of complex systems. Developing skills for quantitative analysis of complex systems. Basics of mathematical modelling. Universality of the methods and transfer of knowledge to other fields. Using computer programs for system dynamics modelling

Predvideni študijski rezultati:	**Intended learning outcomes:**

Znanje in razumevanje: Usvojiti metode za kvalitativno analizo kompleksnih sistemov. Sposobnost opravljanja kvantitativne analize kompleksnih sistemov. Usvojiti osnove matematičnega modeliranja. 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 s primerov iz fizike na področja populacijske dinamike, okoljskih problemov, bioloških sistemov, …	**Knowledge and understanding:** Developing skills for qualitative analysis of complex systems. Developing skills for quantitative analysis of complex systems. Be able to construct basic mathematical models. 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 from examples in Physics to examples in population dynamics, environment and biological systems will be emphasised.

Metode poučevanja in učenja: **Learning and teaching methods:**

Predavanja Teoretične vaje Vaje na računalniku Eksperimentalne vaj	Lectures Theoretical exercises Computer exercises Experiment

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge, projekt)		Type (examination, oral, coursework, project):

ustni izpit pisni izpit seminarska nalog	 **40** **40** **20**	oral exam written exam semina

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]