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
Fizika		**1**	**2**
Physics			

Vrsta predmeta / Course type	obvezni/compulsory
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		105	7

Nosilec predmeta / Lecturer:	Marko Marhl

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

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Pogojev ni.	None.

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. 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, ….	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; 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

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++.

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:

- S. H. Strogatz, Nonlinear Dynamics and Chaos. With Applications to Phzsics, Biology, Chemistry, and Engineering, Perseus Books Publishing, New York (1994).
- 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:

Cilj tega predmeta je, da bodo študenti razumeli, kako kvalitativno in kvantitativno opišemo dinamiko sistemov.
Operativni cilji so:

- predstaviti metode kvalitativne analize kompleksnih sistemov,
- razviti sposobnosti za kvantitativni opis kompleksnih sistemov,
- naučiti študente osnov matematičnega modeliranja,
- poudariti univerzalnost metod in prenos znanja na druga področja,
- naučiti študente uporabljati računalniške programe za modeliranje sistemov (npr. Madonna, ...).

Objectives and competences:

The objective of this course is for students to be able to qualitative and quantitative describe systems dynamics.
The operative objectives are:

- presenting methods for qualitative complex systems analysis,
- developing skills for quantitative analysis of complex systems,
- giving basics of mathematical modelling,
- emphasizing universality of the methods and knowledge transfer to other fields,
- developing skills for using computer programs for system dynamics modelling (e.g. Madonna, …).

Predvideni študijski rezultati:

Znanje in razumevanje:
Po zaključku tega predmeta bo študent sposoben:

- razumeti in uporabiti metode za kvalitativno analizo kompleksnih sistemov,
- razumeti osnove matematičnega modeliranja,

Intended learning outcomes:

Knowledge and understanding:
On completion of this course the student will be able to:

- understand and implement methods for qualitative analysis of complex systems,
- understand basics of mathematical modelling,

- uporabiti metode za kvantitativno analizo kompleksnih sistemov,
- uporabljati računalniške programe za modeliranje sistemske dinamike.

- implement methods for quantitative analysis of complex systems,
- use computer programs for modelling systems dynamics.

Prenesljive/ključne spretnosti in drugi atributi:

- *Spretnosti komuniciranja:* ustni zagovor vaj, pisno izražanje pri pisnem izpitu.
- *Uporaba informacijske tehnologije:* uporaba računalniških programov za modeliranje sistemov.
- *Reševanje problemov:* reševanje problemov z uporabo matematičnega modeliranja dinamike sistemov.
- *Prenos znanja na druga področja:* prenos znanja s primerov iz fizike na področja populacijske dinamike, okoljskih problemov, bioloških sistemov, …

Transferable/Key Skills and other attributes:

- *Communication skills:* oral defense of practical work, manner of expression at written examination.
- *Use of information technology:* use of computer programs for systems modelling.
- *Problem solving:* problem solving with implementing mathematical modelling of systems dynamics.
- *Transfer of knowledge to other fields:* knowledge transfer from examples in physics to examples in population dynamics, environment and biological systems, …

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	**40**	oral exam
pisni izpit	**40**	written exam
seminarska naloga	**20**	seminar work
Za uspešno zaključeno učno enoto mora biti vsak del posebej pozitiven. Opravljena seminarska naloga je pogoj za pristop k izpitu.		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]