

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	Izobraževalna fizika	3	6
Five-year master's degree program Subject Teacher	Educational physics		

Vrsta predmeta / Course type obvezni

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

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

Pogojev ni.

Prerequisites:

None.

Vsebina:

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, ...;

Content (Syllabus outline):

1. Qualitative analysis of complex systems.
 2. Quantitative analysis of the dynamics of complex systems: determination of system variables – the so-called 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

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++.

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++.

Temeljna literatura in viri / Readings:

- S. H. Strogatz, Nonlinear Dynamics and Chaos. With Applications to Physics, 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

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,

<p>modeliranja,</p> <ul style="list-style-type: none"> • uporabiti metode za kvantitativno analizo kompleksnih sistemov, • uporabljati računalniške programe za modeliranje sistemske dinamike. <p>Prenesljive/ključne spretnosti in drugi atributi:</p> <ul style="list-style-type: none"> • <i>Spretnosti komuniciranja:</i> ustni zagovor vaj, pisno izražanje pri pisnem izpitu. • <i>Uporaba informacijske tehnologije:</i> uporaba računalniških programov za modeliranje sistemov. • <i>Reševanje problemov:</i> reševanje problemov z uporabo matematičnega modeliranja dinamike sistemov. • <i>Prenos znanja na druga področja:</i> prenos znanja s primerov iz fizike na področja populacijske dinamike, okoljskih problemov, bioloških sistemov, ...
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<ul style="list-style-type: none"> • implement methods for quantitative analysis of complex systems, • use computer programs for modelling systems dynamics. <p>Transferable/Key Skills and other attributes:</p> <ul style="list-style-type: none"> • <i>Communication skills:</i> oral defense of practical work, manner of expression at written examination. • <i>Use of information technology:</i> use of computer programs for systems modelling. • <i>Problem solving:</i> problem solving with implementing mathematical modelling of systems dynamics. • <i>Transfer of knowledge to other fields:</i> knowledge transfer from examples in physics to examples in population dynamics, environment and biological systems, ...

Metode poučevanja in učenja:

<p>Predavanja Teoretične vaje Vaje na računalniku Eksperimentalne vaje</p>
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Learning and teaching methods:

<p>Lectures Theoretical exercises Computer exercises Experiment</p>

Delež (v %) /
Weight (in %)

Načini ocenjevanja:

<p>Način (pisni izpit, ustno izpraševanje, naloge, projekt):</p> <p>ustni izpit pisni izpit seminarska naloga</p>

Assessment:

<p>Type (examination, oral, coursework, project):</p> <p>oral exam written exam seminar</p>

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](https://doi.org/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](https://doi.org/10.1016/j.apenergy.2019.03.134). [COBISS.SI-ID [1024346460](https://www.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](https://doi.org/10.1371/journal.pone.0171033). [COBISS.SI-ID [22990856](https://www.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](https://doi.org/10.24019/jtavr.20). [COBISS.SI-ID [24300552](https://www.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](https://doi.org/10.3389/fphys.2017.01106). [COBISS.SI-ID [512760376](https://www.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]