Univerza v Mariboru

Fakulteta za naravoslovje in matematiko

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Fizika bioloških sistemov
Course title:	Physics of Biological Systems

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Fizika 1. stopnja		3	5
Physics 1st cycle			

Vrsta predmeta / Course type Izbrni / Elective

Univerzitetna koda predmeta / University course code:

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Lab. vaje** **Lab. work**	**Druge oblike študija**	**Samost. delo** **Individ. work**	**ECTS**
30	**15**	**30**			**105**	**6**

Nosilec predmeta / Lecturer: Aleš Fajmut

Jeziki / Languages:	
Predavanja / Lectures:	slovenski /Slovene
Vaje / Tutorial:	slovenski /Slovene

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

Vsebina:	**Content (Syllabus outline):**
Splošni opis predmeta: Vsebina predmeta temelji na aplikaciji teoretičnih biofizikalnih metod in orodij na biološko orientirane probleme in situacije. Obravnavano bo delovanje različnih kompleksnih bioloških sistemov, kot so metabolični sistemi, signalne mreže, organele, celice, organi, organizmi in populacije z vidika študija in obravnave delovanja njegovih sestavnih delov. Na podlagi razumevanja odnosov in interakcij med pod enotami kompleksnejšega sistema bo na ta način	General description of the subject: The content of the course is based on the application of theoretical biophysical methods and tools to biologically oriented problems and situations. Various complex biological systems, such as metabolic systems, signal networks, organelles, cells, organs, organisms and populations will be treated in terms of the study and treatment of the components and their functioning. Based on an understanding of the relationships and interactions between sub-units of a more complex system, it will also be possible to deduce the functioning of the system as a whole.

mogoče sklepati tudi na delovanje sistema kot celote. Vsebina predavanj: - UVOD: Osnovni gradniki živih sistemov in osnove molekularne biofizike - STANDARDNI PRISTOPI K MODELIRANJU BIOLOŠKIH SISTEMOV: (biokemijska in encimska kinetika, metabolične mreže, kontrolna analiza, signalne mreže, farmakokinetični modeli) - ELEKTROFIZIOLOŠKI MODELI MEMBRANSKE NAPETOSTI: Nernstovo in Donnanovo ravnovesje, Hodgkin-Huxley-Katzov model, modeliranje prepustnosti napetostno reguliranih kanalov - IZBRANI PRIMERI DETERMINISTIČNEGA MODELIRANJA BIOLOŠKIH SISTEMOV: (oscilacije v bioloških sistemih (klacijeve, cirkadni ritmi, ekspresija genov), prenos signalov, krčenje mišic, metabolizem celice, celostno modeliranje delovanja celice) V okviru seminarja študent izbere eno izmed razpisanih tem za projektno nalogo, ki ima obliko krajšega strokovnega prispevka in temelji na že objavljenih modelih, ki opisujejo biološke sisteme. Študent po izdelavi in pregledu naloge pripravi predstavitev pred kolegi. V okviru vaj študentje izdelujejo modele izbranih bioloških sistemov iz vsebin predavanj in jih rešujejo s pomočjo računalniških orodij za numerično in analitično računanje (Berkeley Madonna, Mathematica), vizualizirajo in obdelujejo podatke in rezultate simulacij z računalniškimi orodji (Origin).	Content of lectures: - INTRODUCTION: The basic building blocks of living systems and the basis of molecular biophysics - STANDARD APPROACHES FOR MODELING BIOLOGICAL SYSTEMS: (biochemical and enzymatic kinetics, metabolic networks, control analysis, signaling networks, pharmacokinetic models) - ELECTROPHYSIOLOGICAL MODELS OF MEMBRANE POTENTIAL: Nernst and Donnan equilibrium, Hodgkin-Huxley-Katz model, models for the permeability of voltage operated channels - SELECTED EXAMPLES OF DETERMINISTiC MODELING OF BIOLOGICAL SYSTEMS: (oscillations in biological systems (calcium, circadian rhythms, gene expression), signal transduction, muscle contraction, cell metabolism, whole-cell modelling) The seminar is intended for the presentations of student projects, which should have the form of a shorter professional paper and is based on already published models describing biological systems. After preparing and reviewing the project, the student prepares a presentation in front of colleagues. The tutorials are intended for the treatment of selected models of biological systems from the contents of lectures. Students solve problems by using the computer tools for the numerical and analytical computation (Berkeley Madonna, Mathematica) as well as visualize and analyze the data and simulation results with computer tools (Origin).

Temeljni literatura in viri / Readings:

1. Klipp E., Herwig R., Kowald A., Wierling C., Lehrach H. Systems Biology in Practice, Wiley-VCH, Weinheim 2005
2. Kitano H. Foundations of Systems Biology, MIT Press, Cambridge 2001
3. Voit E.O. Computational Analysis of Biochemical Systems: A Practical Guide for Biochemists and Molecular Biologists, Cambridge University Press, New York 2000
4. Glaser R. Biophysics, Springer 2001

Izročki prosojnic s predavanj in druga dodatna interna študijska literatura v obliki poglavij iz monografij in znanstvenih člankov, ki je v elektronski obliki dostopna na: https://estudij.um.si/ v okviru predmeta Fizika bioloških sistemov.

Handouts from lectures and other additional internal study literature in the form of chapters from monographs and scientific articles, which is available in electronic form at: https://estudij.um.si/ as part of the subject Physics of biological systems.

Cilji in kompetence:

Študent je po uspešno opravljenem izpitu zmožen:
- razumeti obravnavane teoretične biofizikalne koncepte in metode modeliranja živih sistemov od ravni medmolekularnih interakcij do ravni delovanja celice, tkiva in organizma
- identificiranja izbranih enostavnejših problemov v bio-znanostih in ocenitve, kako izbrati in rešiti probleme, pri katerih je teoretični in kvantitativni pristop smiseln in produktiven
- strokovnega sodelovanja, komunikacije ter prenosa znanj na področju naravoslovnih interdisciplinarnih ved

Objectives and competences:

After passing the exam, the student is able:

- to understand the discussed theoretical biophysical concepts and methods of modeling of living systems from the level of intermolecular interactions to the level of the cell, tissue and organism functioning
- to identify simpler problems in bio-sciences and to assess, how to choose and solve problems in cases, in which the theoretical and quantitative approach is meaningful and useful
- of professional cooperation, communication and transfer of knowledge in the field of interdisciplinary natural sciences

Predvideni študijski rezultati:

Znanje in razumevanje:
Po zaključku predmeta je študent zmožen:
- kvalitativno in kvantitativno (s fizikalno-matematičnimi odvisnostmi) opisati obravnavane teoretične biofizikalne koncepte
- aplicirati te koncepte na konkretnih primerih modelov bioloških sistemov
- pridobiti podatke o parametrih modelov z analizo meritev v člankih ali iz podatkovnih baz
- analitično ali z računalniškimi orodji rešiti konkretne obstoječe modele bioloških

Intended learning outcomes:

Knowledge and Understanding:
Upon completion of the course, the student is able to:
- qualitatively and quantitatively (with physical and mathematical dependencies) describe selected theoretical biophysical concepts
- apply these concepts on selected examples of models of biological systems
- acquire data on model parameters by analyzing measurements in articles or from databases

sistemov, z njimi napovedati rezultate in jih interpretirati	- analytically or with help of computer tools to solve selected existing models of biological systems, predict the results and interpret them
Prenesljive/ključne spretnosti in drugi atributi: - sposobnost uporabe računalniških orodij za modeliranje, za analitično in numerično računanje ter analizo podatkov - sposobnost analize izmerjenih podatkov iz znanstvenih objav in zavedanje o njihovem pomenu za modeliranje bioloških sistemov - sposobnost zavedanja o pomenu in koristnosti biofizikalnih teoretičnih pristopov k obravnavi bioloških sistemov za razvoj novih eksperimentov in metod zdravljenja	**Transferable/Key Skills and other attributes:** - the ability to use computer modeling tools, as well as tools for analytical and numerical computation and data analysis - ability to analyze measured data from scientific publications and awareness of their importance for modeling of biological systems - awareness of the importance and usefulness of biophysical theoretical approaches for the treatment of biological systems accounting for the development of new experiments and methods of medical treatment

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja podkrepljena s simulacijami Seminar; pisne in ustne predstavitve projektnih nalog iz izbrane teme Seminarske oziroma računske vaje.	Lectures, supported by simulations Seminar; oral and written presentations of projects from selected topics Tutorials

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Pisni izpit iz vsebin predavanj in vaj	50	Written exam from the topics of lectures and tutorials
Ustni izpit iz vsebin predavanj in vaj	20	Oral exam from the topics of lectures and tutorials
Projektna naloga (pisni izdelek in predstavitev) Izdelana in predstavljena projektna naloga je pogoj za pristop h končnemu preverjanju.	30	Project (written paper and presentation) Written and presented project is required for the approach to the final examination.

Reference nosilca / Lecturer's references:

ŠTERK, Marko, MARKOVIČ, Rene, MARHL, Marko, FAJMUT, Aleš, DOBOVIŠEK, Andrej. Flexibility of enzymatic transitions as a hallmark of optimized enzyme steady-state kinetics and thermodynamics. *Computational biology and chemistry*. [Print ed.]. Apr. 2021, vol. 91, str. 1-10. ISSN 1476-9271. DOI: 10.1016/j.compbiolchem.2021.107449. [COBISS.SI-ID 52543491]

FAJMUT, Aleš, PAL, Kaushik, HARKAI, Saša, ČREŠNAR, Dejvid, KUTNJAK, Zdravko, KRALJ, Samo. The core structure of a laboratory-made dust devil-like vortex and its condensed matter analogs. *Journal of molecular structure*. [Print ed.]. 2021, vol. 1237, str. 30335-1-30335-8. ISSN 0022-2860. DOI: 10.1016/j.molstruc.2021.130335. [COBISS.SI-ID 58279171]

DOBOVIŠEK, Andrej, MARKOVIČ, Rene, BRUMEN, Milan, FAJMUT, Aleš. The maximum entropy production and maximum Shannon information entropy in enzyme kinetics. *Physica. A, Statistical mechanics and its applications*. [Print ed.]. 2018, vol. 496, str. 220-232. ISSN 0378-4371. DOI: 10.1016/j.physa.2017.12.111. [COBISS.SI-ID 23601416]

FAJMUT, Aleš. Molecular mechanisms and targets of cyclic guanosine monophosphate (cGMP) in vascular smooth muscles. V: SAKUMA, Kunihiro (ur.). *Muscle cell and tissue : novel molecular targets and current advances*. London: IntechOpen, cop. 2021. Str. 1-31. ISBN 978-1-83968-651-1, ISBN 978-1-83968-650-4, ISBN 978-1-83968-652-8. https://www.intechopen.com/chapters/76823, DOI: 10.5772/intechopen.97708. [COBISS.SI-ID 79467011]