



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	6
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:

Vaje / Tutorial:

slovenski /Slovene

slovenski /Slovene

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

Priporočeno je predznanje klasične in moderne fizike.

Vsaka obveznost študenta v načinih ocenjevanja mora biti opravljena s pozitivno oceno. Opravljen projekt je pogoj za pristop k pisnemu izpitu.

Prerequisites:

Recommended is preknowledge of classical and modern physics.

Each student requirement within the assessment methods must be completed with a passing grade. Completed project is a prerequisite for taking the written exam.

Vsebina:

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

Content (Syllabus outline):

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

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 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 (klacije, 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

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.

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,

Madonna, Mathematica), vizualizirajo in obdelujejo podatke in rezultate simulacij z računalniškimi orodji (Origin).

Mathematica) as well as visualize and analyze the data and simulation results with computer tools (Origin).

Temeljni literatura in viri / Readings:

1. Kitano H. Foundations of Systems Biology, MIT Press, Cambridge 2001 (<https://plus.cobiss.net/cobiss/si/sl/bib/111056485414564>) – dostopno preko **EBSCOhost Ebook Academic Collection** za študente UM
2. Chappell. (2020). *Physiology for Engineers: Applying Engineering Methods to Physiological Systems*. Springer International Publishing. (<https://plus.cobiss.net/cobiss/si/sl/bib/4100000011223391>) **EBSCOhost Ebook Academic Collection** za študente UM
3. Srivastava, P. K. (2005). *Elementary biophysics: an introduction* (str. XV, 237). Alpha Science International. (<https://plus.cobiss.net/cobiss/si/sl/bib/pefmb/2893076>)
4. Cotterill, R. (2003). *Biophysics: an introduction* (Reprinted, str. XII, 395). J. Wiley & Sons. (<https://plus.cobiss.net/cobiss/si/sl/bib/pefmb/12462600>)
5. Glaser, R. (2012). *Biophysics: an introduction* (2nd ed.). Springer. (<http://dx.doi.org/10.1007/978-3-642-25212-9>)

Izročki prosojnic s predavanj, ki so v elektronski obliki dostopni na: <https://studij.um.si/> v okviru predmeta Fizika bioloških sistemov. Med temeljno literaturo spadajo zgolj izbrana poglavja naštetih knjig, ki so zajeta v vsebini predmeta.

Handouts from lectures which are available in electronic form at: <https://studij.um.si/> as part of the subject Physics of biological systems. Only selected chapters from the listed books that are included in the course content are considered core literature.

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 sistemov, z njimi napovedati rezultate in jih interpretirati

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

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
- analytically or with help of computer tools to solve selected existing models of biological systems, predict the results and interpret them

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:

Predavanja podkrepljena s simulacijami
Seminar; pisne in ustne predstavitve projektnih nalog iz izbrane teme
Seminarske oziroma računske vaje.

Learning and teaching methods:

Lectures, supported by simulations
Seminar; oral and written presentations of projects from selected topics
Tutorials

Delež (v %) /

Načini ocenjevanja:

Weight (in %)

Assessment:

Pisni izpit	50	Written exam
Ustni izpit	20	Oral exam
Projekt	30	Project

Reference nosilca / Lecturer's references:

1. DOBOVIŠEK, Andrej, BLAŽEVIČ, Tina, KRALJ, Samo, FAJMUT, Aleš. Enzyme cascade to enzyme complex phase-transition-like transformation studied by the maximum entropy production principle. Cell reports physical science. 2025, vol. 6, iss. 2, [article no.] 102400, 11 str. ISSN 2666-3864. <https://doi.org/10.1016/j.xcrp.2024.102400>, [COBISS.SI-ID 225246211]
2. DOBOVIŠEK, Andrej, VITAS, Marko, BLAŽEVIČ, Tina, MARKOVIČ, Rene, MARHL, Marko, FAJMUT, Aleš. Self-organization of enzyme-catalyzed reactions studied by the maximum entropy production principle. International journal of molecular sciences. 2023, vol. 24, iss. 10, 21 str. ISSN 1422-0067, DOI: 10.3390/ijms24108734 [COBISS.SI-ID 152729603]
3. 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]