2023/2024

Univerza v Mariboru

Medicinska fakulteta

UČNI NAČRT PREDMETA / SUBJECT SPECIFICATION	
Predmet:	**Izbrane vsebine in novosti v biofiziki in medicinski fiziki**
Subject Title:	**Selected Topics and Novelties in Biophysics and Medical Physics**

Študijski program in stopnja Study programme and cycle	Študijska smer Study option	Letnik Year of study	Semester Semester
Dentalna medicina/Dental Medicine 2. stopnja/2nd cycle		**1**	**1 ali 2**

Vrsta predmeta / Course type Izbirni/Elective

Univerzitetna koda predmeta / University subject code:

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje Clinical training	Druge oblike študija Other forms of study	Samost. delo Individual work	ECTS
5	**40**				**45**	**3**

Nosilec predmeta / Lecturer: **red. prof. dr. Marko Marhl**

Jeziki / Languages: **Predavanja / Lecture:** slovenski/ Slovene
Vaje / Tutorial:

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

Prerequisits:

Vsebina:

Definirani so vsebinski sklopi, znotraj katerih si študentje izberejo posamezne tematike, ki jih preštudirajo in jih nato predstavijo ostalim študentom ter z njimi diskutirajo. Predvidoma se na enem srečanju obravnava en sklop oz. podsklop, ki predstavlja vsebinsko celoto. Vsebinski okvir je fleksibilen in se lahko priredi skupini, ki bi želela modificirati, zamenjati ali dodati nov sklop oz. nove sklope s področja biofizike, biotehnologije ali medicinske fizike.

Vnaprej priipravljeni vsebinski sklopi:

Dinamični sistemi v biologiji in medicini: pozitivne in negativne (regulacijske) zanke, nelinearnost, fluktuacije, kaos; pomen kaosa v fiziologiji in patološke spremembe (npr. bitje srca).

Content (Syllabus outline):

Different topics are proposed for the seminars. Students select particular topics, prepare the presentations for other students, and stimulate discussions. In principle, one topic or a larger part of it is discussed during one seminar. The proposed framework of the seminar topics is flexible and can be adjusted to the needs and interest of a seminar group; it is possible to modify, exchange or add a new topic in the field of biophysics, biotechnology, or medical physics.

Proposed seminar topics:

Dynamical systems in biology and medicine: positive and negative (regulatory) feedback-loops, non-linearity, fluctuations, chaos; the role of chaos in physiology and pathology (e.g. heart beating).

Kalcijeva signalizacija: pulzi in oscilacije koncentracije prostega kalcija v celicah; pomen kalcijeve signalizacije za regulacijo celičnih procesov (npr. kontrakcija mišične celice, delitev celice, eksocitoza) in medcelično signalizacijo (npr. sinhronizacija celic).	Calcium signalling: pulses and oscillations of free calcium concentration in cells; the role of calcium signalling in regulation of cellular processes (e.g. muscle cell contraction, cell division, exocytosis) and intracellular signalling (e.g. synchronisation of cells).
Deterministično in stohastično modeliranje metabolnih procesov: npr. glikolitske oscilacije, encimske reakcije.	Deterministic and stochastic modelling of metabolic processes: e.g. glycolytic oscillations, enzyme reactions.
Mreže: mreže v naravi in družbi, mreže malega sveta, sodobne raziskave fizioloških procesov s teorijo mrež (npr. medcelično povezovanje celic beta v trebušni slinavki in izločanje insulina). Teorija iger: npr. rakave celice in oživitev Warburg efekta in Crabtree efekta (močno povečana citiranost teh del v zadnjem času).	Networks: networks in nature and society, small-world networks, current research of physiological processes with the network theory (e.g. intracellular connections between beta cells in pancreas and insulin secretion). Game theory: e.g. cancer cells and revitalization of Warburg effect and Crabtree effect (a dramatic increase of the citations in the last years).
Fraktali: fizikalna razlaga optimizacije drevesnih sztruktur; npr. optimizacija strukture ožilja in angiogeneze, drevesna struktura pljuč, pomen fraktalov v diagnostiki.	Fractals: physical explanation of optimization of tree-like structures; e.g. optimization of vascular structure and angiogenesis, tree-like structure of the lung, role of fractals in diagnostics.
Samoorganizacija in samoorganizacijska kritičnost: pomen samoorganizacije za normalno delovanje in patologijo možganov in srca; klinične aplikacije pri srčnih spodbujevalnikih.	Self-organization and self-organized criticality: the role of self-organization in physiology and pathology of brain and hart functioning; clinical applications for pacemaker devices.
Skaliranje v naravi: fizikalne omejitve površin in volumnov celic, metabolizem velikih in malih organizmov, Kleiberjev zakon, novosti na področju prokaritskih celic.	Scaling in nature: physical constraints of the cellular surface and volume, metabolic rates of big and small organisms, Kleiber's law, recent studies on prokaryotic cells.
Molekularni motorji: npr. ATP-sintaza.	Molecular motors: e.g. ATP-synthase.
Ionizirajoče sevanje in interakcija s tkivom človeka: primerjava doz sevanj v klinični praksi (npr. rentgen zoba) z dozami iz vsakdanjega življenja (npr. polet čez Atlantik).	Ionizing radiation and interaction with human tissue: comparison of doses in clinical practice (e.g. RTG of teeth) with the doses in everyday life (e.g. a flight across the Atlantic).
Sodobne eksperimentalne metode v diagnostiki in terapiji: npr. CT-rentgen, PET, SPECT, MRI, termografija, endoskopija.	Sophisticated experimental methods in diagnostics and therapies: e.g. X-ray CT, PET, SPECT, MRI, thermography, endoscopy.
Uporaba velikih količin podatkov (»big data«) v medicini: vloga fizike in bionformatike v obravnavi velikih količin podatkov za potrebe sodobne diagnostike in personalizacije medicine.	Big data in medicine: importance of physics and bioinformatics for the analyses of big amounts of data for the purposes of modern diagnostics and personalized medicine.

Temeljni literatura in viri / Textbooks:

- A.-L- Barabási, Network Science, Cambridge University Press, 2016.
- Fractals in Biology and Medicine, Eds: G.A. Losa, D. Merlini, T.F. Nonnenmacher, E.R. Weibel, Birkhäuser Verlag, 2005.
- M. D. Lytras, P. Papadopoulou, Applying Big Data Analytics in Bioinformatics and Medicine, IGI Global, 2017.

Dopolnilno gradivo:

- D. J. Watts, Small Worlds: The Dynamics of Networks between Order and Randomness, Princeton University Press, 2003.
- S. Camazine, J.-L. Deneubourg, N. R. Franks, J. Sneyd, G. Theraulaz, E. Bonebeau, Self-Organization in Biological Systems, Princeton University Press, 2001.
- P. Back, How Nature Works, Springer Verlag, 1996.
- R. Heinrich, S. Schuster, The Regulation of Cellular Scystems. Chapman & Hall, 1996.

Cilji:	**Objectives:**
Na osnovi fizikalnih konceptov in zakonitosti ter biofizikalnih mehanizmov usvojiti razumevanje fizikalnih procesov v naravi in še posebej v človeškem organizmu. Spoznati povezavo teh konceptov z aplikacijami v diagnostičnih in terapevtskih metodah medicinske fizike. Doseči kompetence samostojne obravnave izbrane teme ter njene predstavitve svojim kolegom v seminarju v ustrezni pisni in ustni obliki.	On the basis of physical concepts and laws, as well as biophysical mechanisms understand physical processes in nature and in particular in the human body. These concepts should be linked with applications in advanced diagnostic methods and therapeutic methods of medical physics. To achieve competences of self-treatment of a selected topic and its presentation to their colleagues in a seminar in appropriate oral and written form.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: Študentje usvojijo razumevanje različnih procesov v biologiji in fiziologiji na osnovi fizikalnih konceptov in zakonov ter biofizikalnih mehanizmov in modelov. Razumejo osnovne principe delovanja eksperimentalne opreme v diagnostiki in terapiji. Prenesljive/ključne spretnosti in drugi atributi: Študentje znajo uporabiti biofizikalne modele za obravnavo strukture in funkcije izbranih bioloških sistemov in primerov iz fiziologije človeka. Znajo samostojno raziskati izbran problem in ga predstaviti v pisni in ustni obliki v seminarju.	Knowledge and Understanding: Students get understanding of various processes in biology and physiology based on concepts and laws in physics as well as on biophysical mechanisms and models. They understand the basic physical principles of experimental equipment in diagnostics and therapy. Transferable/Key Skills and other attributes: Students are able to use biophysical models for discussing structure and function of selected biological systems and cases in human physiology. They are able to explore the chosen problem and present it in oral and written form in the seminar.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja Seminar	Lectures Seminars ~~Seminar work.~~

Načini ocenjevanja:	**Delež (v %) / weight (in %)**	**Assessment:**

Seminar: Seminarska naloga (pisna). Ustna predstavitev seminarske naloge. ŠTUDIJSKE OBVEZNOSTI ŠTUDENTOV: Obvezna prisotnost na seminarjih. Izdelava pisne seminarske naloge. Ustna predstavitev seminarske naloge in diskusija. POGOJI ZA PRISTOP K POSAMEZNEMU PREVERJANJU ZNANJA: Pravočasno oddana pisna seminarska naloga. Pravočasno oddana priprava na ustno predstavitev seminarske naloge.	**50%** **50%**	Seminar: Seminar work (written). Oral presentation of the seminar work. ACADEMIC OBLIGATIONS OF STUDENTS: Compulsory participation at seminars. Seminar work written. Oral presentation of the seminar work with discussions. REQUIREMENTS FOR ACCESS TO INDIVIDUAL KNOWLEDGE CHECKING: Written seminar work which has to be submitted to the lecturer on time. Arrangements of the oral presentation discussed with the lecturer on time.

Reference nosilca / Lecturer's references: prof. dr. Marko MARHL

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].

GOSAK, Marko, MARKOVIČ, Rene, FAJMUT, Aleš, **MARHL, Marko**, HAWLINA, Marko, ANDJELIĆ, Sofija. The analysis of intracellular and intercellular calcium signaling in human anterior lens capsule epithelial cells with regard to different types and stages of the cataract. *PloS one*, ISSN 1932-6203, 2015, vol. 10, iss. 12. http://dx.doi.org/10.1371/journal.pone.0143781, doi: 10.1371/journal.pone.0143781. [COBISS.SI-ID 2645676].

GOSAK, Marko, STOŽER, Andraž, MARKOVIČ, Rene, DOLENŠEK, Jurij, **MARHL, Marko**, RUPNIK, Marjan, PERC, Matjaž. The relationship between node degree and dissipation rate in networks of diffusively coupled oscillators and its significance for pancreatic beta cells. *Chaos*, ISSN 1054-1500, July 2015, vol. 25, iss. 7, 073115-1-073115-8, doi: 10.1063/1.4926673. [COBISS.SI-ID 512523576].

STOŽER, Andraž, GOSAK, Marko, DOLENŠEK, Jurij, PERC, Matjaž, **MARHL, Marko**, RUPNIK, Marjan, KOROŠAK, Dean. Functional connectivity in islets of Langerhans from mouse pancreas tissue slices. *PLoS computational biology*, ISSN 1553-734X. [Print ed.], Feb. 2013, vol. 9, iss. 2, str. e100292312-1-e1002923-12, doi: 10.1371/journal.pcbi.1002923. [COBISS.SI-ID 512264760].

BODENSTEIN, Christian, GOSAK, Marko, SCHUSTER, Stefan, **MARHL, Marko**, PERC, Matjaž. Modeling the seasonal adaptation of circadian clocks by changes in the network structure of the suprachiasmatic nucleus. *PLoS computational biology*, ISSN 1553-734X. [Print ed.], Sep. 2012, vol. 8, iss. 9, e1002697-1-e1002697-12, doi: 10.1371/journal.pcbi.1002697. [COBISS.SI-ID 19375368].