2021/2022

Univerza v Mariboru

Medicinska fakulteta

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Ime predmeta:	Biofizika
Course title:	Biophysics

Študijski program in stopnja Study programme and cycle	Študijska smer Study option	Letnik Year of study	Semester Semester
Splošna medicina, enovit magistrski študijski program		Prvi	1.
General medicine, Uniform master's degree study program		First	1st

Vrsta predmeta (obvezni ali izbirni) / Course type (compulsory or elective)	obvezni compulsory
Univerzitetna koda predmeta / University course code:	

Predavanja Lectures	Seminar Seminar	Vaje Tutorial			Klinične vaje Clinical training	Druge oblike študija Other forms of study	Samost. delo Individual work	ECTS
		AV	LV	RV				
15	15		30				60	4

Nosilec predmeta / Course coordinator:	Prof. dr. Marko Marhl, doc. dr. Andrej Dobovišek
Jeziki /Languages: **Predavanja / Lectures:**	slovenski/slovene
Vaje / Tutorial:	slovenski/slovene

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	Prerequisites for enrolling in the course or for performing study obligations:

Vsebina (kratek pregled učnega načrta):	Content (syllabus outline):
Biomehanika človeškega telesa: Izbrani primeri iz biomehanike skeleta in mišic (sila, navor, delo, energija, mehanska napetost in deformacije) Dinamika tekočin in krvni obtok: Tok neviskoznih in viskoznih tekočin; tlak v mirujočih tekočinah, laminarni in turbolentni tok tekočine, Reynoldsovo število, Bernoullijeva enačba in Hagen-Poiseuillov zakon.	Biomechanics of the human body: Selected cases from biomechanics of skeleton and muscles (force, torque, work, energy, mechanic stress and deformations). Fluid dynamics and blood circulation: The flow of non-viscous and viscous fluids; hydrostatics pressure, laminar and turbulent fluid flow, Reynolds number, Bernoulli equation and Hagen-Poiseuille equation.

Električni pojavi v človeškem telesu: Električni tok, napetost in električna upornost. Ohmov zakon. Struktura celične membrane, lipidni dvosloj. Celična membrana kot električni kondenzator. Membranski potenciali: Nernstov potencial, Donnanov potencial, elektrodifuzijski potencial. Električni monopol in dipol, polarne molekule kot električni dipoli. Molekula vode kot električni dipol. Srce kot električni dipol.	Electric phenomena in the human body: electric current, voltage and electrical resistance Ohm's law. The structure of the cell membrane, the lipid bilayer. Electric current, voltage and electric resistance; Ohm's law. The structure of the cell membrane, the lipid bilayer. Cell membrane as an electric capacitor. The cell membrane potential: Nernst potential, Donnan's potential, electro-diffusion potential. Electric monopoly and dipole, polar molecules such as electric dipoles, the water molecule and heart like electric dipoles.
Energijske pretvorbe v človeškem telesu: Obravnava energijjskih pretvorb v celici z osnovnimi termodinamskimi zakoni. Prvi in drugi zakon termodinamike. Ravnovesno in stacionarno stanje celice. Prosta energija, entropija in (elektro)kemijski potencial. Celični metabolizem.	Energy conversion in human body: Treatment of energy conversion in the cell with the basic thermodynamic laws. The first and second law of thermodynamics. The equilibrium and steady state of the cells. Free energy, entropy and (electro) chemical potential. Cellular metabolism.
Zvok in biofizika ušesa: Zvok kot mehansko valovanje. Vrste zvoka, jakost zvoka in fiziološke enote, meje slišnosti človeškega ušesa, Dopplerjev pojav. Ultrazvok: Uporaba ultrazvoka v klinični praksi.	Sound and biophysics of the ear: Sound as mechanical waves. Types of sound, sound intensity and the physiological units, limits of audibility of the human ear. Doppler effect. Ultrasound: Application of ultrasound in clinical practice.
Svetloba in biofizika očesa: Svetloba kot elektromagnetno valovanje. Obravnava tankih leč; preprost model očesa, daljnovidnosti in kratkovidnosti. Optične naprave, mikroskop. Uporaba svetlobnih tehnik v klinični praksi: Laserji, svetlobna vlakna, endoskopija	Light and biophysics of the eye: Light as electromagnetic waves. Imaging with thin lenses; a simple model of the eye, farsightedness and nearsightedness. Optical devices, microscope. Applications of light techniques in clinical practice: Laser, fibre optics, endoscopy.
Zgradba snovi in radioaktivnost: Bohrov model atoma. Zgradba in stabilnost atomskega jedra. Interakcija ionizirajočega sevanja s tkivom. Zaščita pred sevanji. Dozimetrija.	Structure of matter and radioactivity: Bohr atomic model. Structure and stability of atomic nucleus. The interaction of ionizing radiation with human tissue. Protection against the radiation. Dosimetry.
Fizikalne osnove nekaterih radioloških metod. Rentgenski (RTG žarki: njihov nastanek, spekter in absorpcija RTG žarkov. Uporaba v diagnostiki, absorpcija rentgenskih žarkov v snovi in RTG slikanje, CT rentgen. Ultrazvok: Uporaba ultrazvoka v klinični praksi (meritev hitrosti krvi, meritev velikosti bioloških struktur, primer: premer žile). Magnetna resonanca (MR) z upodabljanjem (MRI) PET /CT– emisija pozitrona / računalniška tomografija(CT) SPET /CT – emisija posameznega fotona /računalniška tomografija (CT) Vpliv ionizirajočega sevanja na humano tkivo. Dozimetrija.	Physical fundamentals of some radiological methods. X-rays (X-ray beams: their origins, and the absorption spectrum of X-ray radiation. The use in diagnostic, X-ray absorption in the material, and x-ray imaging, X-ray CT. Ultrasound: Ultrasound in clinical practice (measurement of blood flow, measurement of the size of biological structures, such as the diameter of blood vessels). Magnetic resonance (MR) imaging (MRI) PET / CT positron emission computed tomography / computed tomography (CT) SPET / CT - single photon emission / computed tomography - The impact of ionizing radiation on human tissue. Dosimetry.
Kratek pregled vsebin laboratorijskih vaj pri predmetu biofizika: - Sile v mišicah in sklepih, težišče človeškega telesa; - Merjenje moči mišic na nogah - Hranilna vrednost živil in energijske porabe energije v organizmu; - Hidromehanika in hemodinamika;	A brief overview of the experiments on the subject of biophysics:

- Električni in magnetni pojavi in meritve EKG; - Merjenje membranskega električnega potenciala; - Hitrost zvoka, impedanca, meritve z ultrazvokom v medicini; - Dopplerjev ultrazvok in laserska Dopplerjeva anemometrija; - Model človeškega očesa in korekcija vida; - Svetloba kot valovanje in valovna narava delcev; - RTG žarki; - Vzbujena stanja atomov in črtasti spektri.	Forces in muscles and joints, center of gravity of human body; - Measurements of muscle strength at vertical jump; - The nutritional value of food and energy consumption in human organism; - Hydromechanics and hemodynamics; - Electrical and magnetic phenomena, and measurements of ECG; - Measurements of membrane (electrical) potential; - Speed of sound, impedance, and measurements with ultrasound in medicine; - Ultrasound Doppler shift and laser Doppler anemometry; - Human eye model and vision corrections; - Light as waves and the wave nature of mass particles; - X-rays; - Excited states of atoms and line spectra.

Temeljni literatura in viri / Reading materials:

1. R. Glaser, Biophysics: An Introduction, Springer-Verlag, 2012.
2. J. Newman: Physics of the Life Sciences, Springer Science+Bussiness Media, LLC, 2008.

Dopolnilno gradivo:

3. P. F. Dillon, Biophysics: A Physiological Approach, Cambridge University Press, 2012.
4. S. Amador Kane, Introduction to Physics in Modern Medicine. CRC Press, 2009.
5. Diagnostična in intervencijska radiologija. Splošni del. Urednik V. Jevtič, sourednika M. Šurlan, J. Matela. Založba Pivec, 2014.
6. P. K. Skrivastava: Elementary Biophysics, An Introduction, Alpha Science International Ltd., Harrow, U.K., 2005.

Cilji in kompetence:

Osvojiti osnovne fizikalne koncepte in zakonitosti pomembne za razumevanje fizikalnih aspektov bioloških procesov na ravneh organizma, organa, tkiva in celic ter supramolekularnih in makromolekularnih struktur. Poseben poudarek je namenjen uporabi fizike v radiologiji in njenim fizikalnim osnovam ter nekaterim kliničnim primerom, ki so izbrani za ilustracijo posameznih radioloških metod. Študentom želimo približati izbrane fizikalne pojave, ki so osnova fizioloških procesov v človeškem organizmu ter nekaterih metod v diagnostiki in zdravljenju.

Objectives and competences:

To attain the knowledge of the fundamental concepts and laws in physics important for mainly qualitative understanding various biological processes running on different levels of biological organisation such as organisms, organs, tissues, cells, and supramolecular and macromolecular structures. To get acquainted with phenomena in physics which serve as fundamental understanding of physiological processes in human as well as of some diagnostic methods and methods of medical treatment.

Predvideni študijski rezultati:

Znanje in razumevanje:
Študentje osvojijo znanje temeljnih fizikalnih konceptov in zakonov potrebnih za razumevanje procesov v biologiji in fiziologiji človeka ter spoznajo aplikacije teh konceptov v medicini in klinični praksi.
Prenesljive/ključne spretnosti in drugi atributi:
Študentje znajo uporabiti preproste fizikalne in matematične modele za študij strukture in funkcije izbranih bioloških sistemov in primerov iz humane fiziologije. Študentje si razširijo razgledanost na področju

Intended learning outcomes:

Knowledge and understanding:
Students get knowledge of fundamental concepts and laws which are important for understanding of processes in human biology and physiology, as well as learn about the applications of these concepts in medicine and clinical practice.
Transferable/Key Skills and other attributes:
Students are able to use simple mathematical models for studies of structure and function of selected biological systems and cases in human physiology. They become

naravoslovja. Znajo analizirati in interpretirati izmerjene eksperimentalne podatke.	well broadly versed in science. They know how to present and interpret their measured experimental data.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja. Seminar. Laboratorijske vaje.	Lectures. Course work. Lab work.

Načini ocenjevanja:	Delež (v %) / Share (in %)	**Assessment methods:**
Sklepni kolokvij iz laboratorijskih vaj oziroma pisni izpit Seminar Ustni izpit ŠTUDIJSKE OBVEZNOSTI ŠTUDENTOV 1. Opravljene laboratorijske vaje. Obvezna prisotnost na vajah. Opravljene vse laboratorijske vaje in izdelana poročila o vseh laboratorijskih vajah po programu. 2. Opravljen seminar (obvezna prisotnost, aktivna udeležba, izdelana in učitelju oddana seminarska naloga ter predstavljena v seminarju. 3. Opravljen ustni izpit s pozitivno oceno. POGOJI ZA PRISTOP K USTNEMU IZPITU: -opravljene laboratorijske vaje, -opravljen seminar - pozitiven sklepni kolokvij iz laboratorijskih vaj ali pozitiven pisni izpit (pozitivno opravljen sklepni kolokvij iz vaj nadomesti pisni izpit).	40% 20% 40%	Final test on lab work or written exam Course work. Oral examination. ACADEMIC OBLIGATIONS OF STUDENTS: Lab work completed (obligatory participation, measurements and reports completed, final test on lab work or written exam) Course work done (obligatory and active participation, written and/or oral presentation) Oral examination done REQUIREMENTS FOR ACCESS TO INDIVIDUAL KNOWLEDGE CHECKING: - lab work completed, - seminar work completed, positive written exam (written exam can be recognized on the basis of partial written examinations).

Reference nosilca / Course coordinator's references: prof. dr. Marko Marhl

GOSAK, Marko, GUIBERT, Christelle, BILLAUD, Marie, ROUX, Etienne, **MARHL, Marko**. The influence of gap junction network complexity on pulmonary artery smooth muscle reactivity in normoxic and chronically hypoxic conditions. *Experimental physiology*, ISSN 0958-0670, 2014, vol. 99, no. 1, str. 272-285, doi: 10.1113/expphysiol.2013.074971. [COBISS.SI-ID 20068872], [JCR, SNIP, WoS]

MARKOVIČ, Rene, GOSAK, Marko, **MARHL, Marko**. Broad-scale small-world network topology induces optimal synchronization of flexible oscillators. *Chaos, solitons and fractals*. [Print ed.], 2014, vol. 69, str. 14-21. http://dx.doi.org/10.1016/j.chaos.2014.08.008. [COBISS.SI-ID 20845576], [JCR, SNIP, WoS]

MARKOVIČ, Rene, GOSAK, Marko, REPNIK, Robert, KRALJ, Samo, **MARHL, Marko**. Defects in planar cell polarity of epithelium : what can we learn from liquid crystals?. V: IGLIČ, Aleš (ur.), KULKARNI, Chandrashekhar (ur.). *Advances in*

planar lipid bilayers and liposomes, (Advances in planar lipid bilayers and liposomes, ISSN 1554-4516, vol. 20). Amsterdam [etc.]: Elsevier: Academic Press. cop. 2014, str. 197-217, ilustr., doi: 10.1016/B978-0-12-418698-9.00008-3. [COBISS.SI-ID 20825864], [WoS, Scopus]

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]

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]

Reference nosilca / Lecturer's references: doc. dr. Andrej Dobovišek

JURETIĆ, Davor, BONAČIĆ LOŠIĆ, Željana, KUIĆ, Domagoj, SIMUNIĆ, Juraj**, DOBOVIŠEK, Andrej**. The maximum entropy production requirement for proton transfers enhances catalytic efficiency for β-lactamases. *Biophysical chemistry*, ISSN 0301-4622. [Print ed.], Jan. 2019, vol. 244, str 11-21, ilustr., doi: 10.1016/j.bpc.2018.10.004. [COBISS.SI-ID 24237832], [JCR, SNIP, WoS do 4. 1. 2019: št. citatov (TC): 0, čistih citatov (CI): 0, Scopus do 15. 12. 2018: št. citatov (TC): 0, čistih citatov (CI): 0]
financer: ARRS, Programi, P1-0055 (B), SI, Biofizika polimerov, membran, gelov, koloidov in celic

VITAS, Marko**, DOBOVIŠEK, Andrej**. In the beginning was a mutualism : on the origin of translation. *Origins of life and evolution of the biospheres*, ISSN 0169-6149, 2018, str. 1-21, ilustr., doi: 10.1007/s11084-018-9557-6. [COBISS.SI-ID 23839496], [JCR, SNIP, WoS do 10. 8. 2018: št. citatov (TC): 0, čistih citatov (CI): 0, Scopus do 4. 8. 2018: št. citatov (TC): 0, čistih citatov (CI): 0]

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*, ISSN 0378-4371. [Print ed.], 2018, vol. 496, str. 220-232, doi: 10.1016/j.physa.2017.12.111. [COBISS.SI-ID 23601416], [JCR, SNIP, WoS do 13. 1. 2019: št. citatov (TC): 3, čistih citatov (CI): 2, Scopus do 15. 12. 2018: št. citatov (TC): 4, čistih citatov (CI): 3]

DOBOVIŠEK, Andrej, VITAS, Marko, BRUMEN, Milan, FAJMUT, Aleš. Energy conservation and maximal entropy production in enzyme reactions. *Biosystems*, ISSN 0303-2647. [Print ed.], 2017, vol. 158, str. 47-56, doi: 10.1016/j.biosystems.2017.06.001. [COBISS.SI-ID23218696], [JCR, SNIP, WoS do 13. 1. 2019: št. citatov (TC): 2, čistih citatov (CI): 2, Scopus do 29. 12. 2018: št. citatov (TC): 2, čistih citatov (CI): 2]

VITAS, Marko, **DOBOVIŠEK, Andrej**. On a quest of reverse translation. *Foundations of chemistry*, ISSN 1386-4238, 2017, vol. 19, iss. 2, str. 139-155, doi: 10.1007/s10698-016-9260-5. [COBISS.SI-ID 22581768], [JCR, SNIP, WoS do 27. 8. 2018: št. citatov (TC): 1, čistih citatov (CI): 0]