2026/2027

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
15	15	**AV**	**LV**	**RV**			60	4
			30					

Nosilec predmeta / Course coordinator:	red. 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:

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 (80 %), aktivna udeležba, izdelana in učitelju oddana seminarska naloga ter predstavljena v seminarju).

3. Opravljen pisni izpit s pozitivno oceno.

POGOJI ZA PRISTOP K PISNEMU IZPITU:

- opravljene laboratorijske vaje,
- opravljen seminar.

Prerequisites for enrolling in the course or for performing study obligations:

ACADEMIC OBLIGATIONS OF STUDENTS:

1. Lab work completed (obligatory participation, measurements and reports completed).

2. Seminar work done (obligatory (80 %) and active participation, written and oral presentation).

3. Written exam done.

REQUIREMENTS FOR ACCESS TO THE WRITTEN EXAM:

- lab work completed,
- seminar work completed.

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)	Biomechanics of the human body: Selected cases from biomechanics of skeleton and muscles (force, torque, work, energy, mechanic stress and deformations).
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.	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.	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

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. 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; - 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.	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. A brief overview of the experiments on the subject of biophysics: 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:	Objectives and competences:
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.	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:	Intended learning outcomes:
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 naravoslovja. Znajo analizirati in interpretirati izmerjene eksperimentalne podatke.	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 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:
Način (pisni izpit, ustno izpraševanje, naloge, projekt):		Type (examination, oral, coursework, project):
Seminarska naloga	30	Seminar paper
Pisni izpit	70	Written exam
Opomba:		Note:
Pisni izpit lahko nadomestijo pozitivno opravljeni sprotni kolokviji.		Written exam can be recognized on the basis of midterm exams.

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

GRUBELNIK, Vladimir, ZMAZEK, Jan, **MARHL, Marko**. The synergistic impact of glycolysis, mitochondrial OxPhos, and PEP cycling on ATP production in beta cells. *International journal of molecular sciences*. 2025, vol. 26, iss. 4, 17 str., ilustr. ISSN 1422-0067. https://doi.org/10.3390/ijms26041454, Digitalna knjižnica Univerze v Mariboru – DKUM, DOI: 10.3390/ijms26041454, DOI: 20.500.12556/DKUM-91817. [COBISS.SI-ID 225604099]

MARHL, Marko. What do stimulated beta cells have in common with cancer cells?. *Biosystems*. [Print ed.]. Aug. 2024, vol. 242, [article no.] 105257, 11 str. ISSN 0303-2647. Digitalna knjižnica Univerze v Mariboru – DKUM, DOI: 10.1016/j.biosystems.2024.105257, DOI: 20.500.12556/DKUM-89336. [COBISS.SI-ID 200576771]

GRUBELNIK, Vladimir, ZMAZEK, Jan, GOSAK, **Marko, MARHL, Marko**. The role of anaplerotic metabolism of glucose and glutamine in insulin secretion : a model approach. *Biophysical chemistry*. [Print ed.]. 2024, vol. 311, [article no.] 107270, 16 str., ilustr. ISSN 0301-4622. https://www.sciencedirect.com/science/article/pii/S0301462224000991?via%3Dihub, Digitalna knjižnica Univerze v Mariboru – DKUM, DOI: 10.1016/j.bpc.2024.107270, DOI: 20.500.12556/DKUM-89024. [COBISS.SI-ID 197803779]

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

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, Digitalna knjižnica Univerze v Mariboru – DKUM, DOI: 10.1016/j.xcrp.2024.102400, DOI: 20.500.12556/DKUM-91789. [COBISS.SI-ID 225246211]

VITAS, Marko, **DOBOVIŠEK, Andrej**. A possible origin of life in nonpolar environments. *Biosystems*. [Print ed.]. Jan. 2025, vol. 247, [article no.] 105384, str. 1-8. ISSN 0303-2647. DOI: 10.1016/j.biosystems.2024.105384. [COBISS.SI-ID 222336003]

VITAS, Marko, **DOBOVIŠEK, Andrej**. Is Darwinian selection a retrograde driving force of evolution?. *Biosystems*. [Print ed.]. Nov. 2023, vol. 233, [article no.] 105031, 8 str. ISSN 0303-2647. DOI: 10.1016/j.biosystems.2023.105031. [COBISS.SI-ID 165759235], [JCR, SNIP, WoS, Scopus]

DOBOVIŠEK, Andrej, AMBROŽIČ, Milan, KUTNJAK, Zdravko, KRALJ, Samo. Liquid crystal based active electrocaloric regenerator. *Heliyon*. Mar. 2023, vol 9, iss. 3, [article no.] e14035, str. 1-12, ilustr. ISSN 2405-8440. https://www.sciencedirect.com/science/article/pii/S2405844023012422?via%3Dihub, DOI: 10.1016/j.heliyon.2023.e14035. [COBISS.SI-ID 143422211], [JCR, SNIP, WoS, Scopus]

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], [JCR, SNIP, WoS, Scopus]