2023/2024

Univerza v Mariboru

Medicinska fakulteta

UČNI NAČRT PREDMETA / SUBJECT SPECIFICATION	
Predmet:	**Osnove biofizike**
Subject Title:	**Basics of Biophysics**

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**

Vrsta predmeta / Course type Obvezni/ Compulsory

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
15	**15**	**30**			**60**	**4**

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

Jeziki / Languages:	**Predavanja / Lecture:**	slovenščina/slovene
	Vaje / Tutorial:	slovenščina/slovene

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

Prerequisits:

Vsebina:

Biomehanika: Osnove biomehanike skeleta in mišic s poudarkom na čeljusti in obraznih mišicah; sile, navori, energija, delo, toplota. Mehanske lastnosti materialov, ki se uporabljajo v zobozdravstvu (mehanske napetosti, 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.

Energijske pretvorbe v človeškem telesu: Dnevne potrebe po energiji, celični metabolizem. Osnove termodinamike, prvi in drugi zakon termodinamike. Podobnosti in razlike energijskih pretvorb v našem telesu v primerjavi z delovanjem toplotnih strojev. Termodinamski potenciali, kemijski potencial.

Tokovi nenabitih delcev in ravnovesje: Ravnovesno in stacionarno stanje celice. Prvi Fickov zakon, difuzijska

Content (Syllabus outline):

Biomechanics: Basics of biomechanics of skeleton and muscles with emphasis on the jaw and facial muscles; force, torque, energy, work, heat. Mechanical properties of materials used in dentistry (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.

Energy conversion in the human body: Daily energy consumption, cellular metabolism. Basics of thermodynamics, the first and the second law of thermodynamics. Similarities and key differences between energy conversion in the human body and acting of heat engines. Thermodynamic potentials, chemical potential.

Fluxes of non-charged particles and equilibrium: The equilibrium and the steady state of cells. The first Fick's

enačba, prehajanje nenabitih delcev preko celične membrane, transport respiratornih plinov v pljučih, osmoza.	law, diffusion equation, transport of non-charged particles across the cell membrane, transport of respiratory gases in lung; osmosis.
Električni pojavi v človeškem telesu: Električni tok, napetost in električna upornost. Celična membrana kot električni kondenzator. Membranski potencial; Nernstova enačba, Donnanovo ravnovesje, elektrodifuzijski potencial. Električni monopol in dipol, polarne molekule kot električni dipoli. Srce kot električni dipol.	Electric phenomena in human body: Electric current, voltage and electrical resistance. Cell membrane as an electric capacitor. The membrane potential; Nernst equation, Donnan equilibrium, electro-diffusion potential. Electric monopoly and dipole, polar molecules as electric dipoles. Heart acting as an electric dipole.
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. Magnetna resonanca (MR) z upodabljanjem (MRI) PET/CT – pozitronska emisijska tomografija / računalniška tomografija. SPECT – enofotonska emisijska računalniška tomografija.	Physical fundamentals of some radiological methods. X-rays: their origins, X-ray spectrum and the absorption of X-ray beams. The use in diagnostics, X-ray absorption in the material and X-ray imaging, X-ray CT. Magnetic resonance (MR) with imaging (MRI) PET/CT – positron emission tomography / computed tomography. SPECT – single-photon emission computed tomography.
Kratek pregled vsebin laboratorijskih vaj pri predmetu Osnove biofizike: - meritve zmogljivosti mišic - sile in navori, ki se pojavijo v mišicah in čeljusti pri žvečenju - merjenje tlaka in krvnega tlaka - merjenje pretoka tekočin - leče, lupa, mikroskop, model očesa - daljnovidnost in kratkovidnost - določanje velikosti slepe pege in določanje gostote fotoreceptorjev na očesnem ozadju - merjenje električnih količin, Ohmov zakon - merjenje membranskega potenciala - elektrokardiografija - spektri svetlobe in optična spektrometrija - spektri zvoka, ton, zven, šum - rentgenski žarki	A brief overview of the experiments on the subject of Basics of biophysics: - measurements of muscle strength - forces and torques exerted by the masseter muscle in the jaw - measurements of pressure and blood pressure - measurement of fluid flow - lenses, loupe, microscope, a model of human eye - farsightedness and nearsightedness. - determination of the size of blind spot and the density of photoreceptors in the eye - measurements of electrical quantities, Ohm's law - measurement of membrane potential - electrocardiography - light spectra and optical spectrometry - sound spectra, pure tone, complex tone, noise

- osnove ultrazvočnih meritev v medicini - izbrani teoretični in računski primeri iz radiologije: obsevanje tumorjev.	- X-rays - basics of ultrasound measurements in medicine - selected theoretical and computational examples in radiology: irradiation of tumours.

Temeljni literatura in viri / Textbooks:

1. R. Glaser, Biophysics: An Introduction, Springer-Verlag, 2012.
2. P. F. Dillon, Biophysics: A Physiological Approach, Cambridge University Press, 2012.
3. J. Newman: Physics of the Life Sciences, Springer Science+Bussiness Media, LLC, 2008.

Dopolnilno gradivo:

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.

Cilji:	**Objectives:**
Usvojiti osnovne fizikalne koncepte in zakonitosti, ki so pomembni za razumevanje fizikalnih aspektov bioloških procesov na ravni organizma, organa, tkiva in celic ter supramolekularnih in makromolekularnih struktur. Seznaniti se s ključnimi fizikalnimi procesi, ki dajejo osnovo za razumevanje fizioloških procesov v človeškem telesu, kakor tudi spoznati možnosti aplikacij v diagnostiki in zdravljenju.	To attain knowledge of the fundamental concepts and laws in physics important for understanding of different biological processes at levels of whole organisms, organs, tissues, cells, and supramolecular and macromolecular structures. To get acquainted with phenomena in physics which enable fundamental understanding of physiological processes in human body, as well as indicate their applications in diagnostics and medical treatments.
Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: Študentje usvojijo 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 koncepte in matematične modele za študij strukture in funkcije bioloških sistemov in primerov iz fiziologije človeka. Študentje si razširijo razgledanost na področju naravoslovja. Znajo analizirati in interpretirati izmerjene eksperimentalne podatke.	Knowledge and understanding: Students get knowledge of fundamental physical 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 physical concepts and mathematical models for studies of structure and function of 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 Vaje (laboratorijske)	Lectures Seminars Tutorial (laboratory)

Načini ocenjevanja:	**Delež (v %) / weight (in %)**	**Assessment:**
Seminar	30%	Seminar work.
Pisni izpit	70%	Written exam.

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, pred študenti predstavljena in učitelju oddana seminarska naloga. 3. Opravljen pisni izpit s pozitivno oceno. POGOJI ZA PRISTOP K PISNEMU IZPITU: - opravljene laboratorijske vaje, - opravljen seminar. Pisni izpit lahko nadomestijo pozitivno opravljeni sprotni kolokviji.		ACADEMIC OBLIGATIONS OF STUDENTS: 1. Lab work completed (obligatory participation, measurements and reports completed). 2. Seminar work done (obligatory and active participation, written and oral presentation). 3. Written examin done REQUIREMENTS FOR ACCESS TO THE WRITTEN EXAM: Lab work completed and seminar work done. Written exam can be recognized on the basis of partial written examinations.

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, 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].
GOSAK, Marko, DOLENŠEK, Jurij, MARKOVIČ, Rene, RUPNIK, Marjan, **MARHL, Marko**, STOŽER, Andraž. Multilayer network representation of membrane potential and cytosolic calcium concentration dynamics in beta cells. *Chaos, solitons and fractals*. [Print ed.], 2015, vol. 80, str. 76-82, ilustr. http://www.sciencedirect.com/science/article/pii/S0960077915001794, doi: 10.1016/j.chaos.2015.06.009. [COBISS.SI-ID 512513080].
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].
MARKOVIČ, Rene, STOŽER, Andraž, GOSAK, Marko, DOLENŠEK, Jurij, **MARHL, Marko**, RUPNIK, Marjan. Progressive glucose stimulation of islet beta cells reveals a transition from segregated to integrated modular functional connectivity patterns. *Scientific reports*, ISSN 2045-2322, vol. 5, 2015, 10 str. http://www.nature.com/srep/2015/150119/srep07845/full/srep07845.html, doi: 10.1038/srep07845. [COBISS.SI-ID 512466488].