

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Meritve in senzorji v biomedicini
Course title:	Measurements and Sensors in Biomedicine

Študijski programi in stopnja	Študijska smer	Letnik	Semestri
Elektrotehnika, druga stopnja, magistrski	Biomedicinska tehnika (smer)	1. letnik	Zimski

Univerzitetna koda predmeta/University course code: 64210

Predavanja	Seminar	Vaje	Klinične vaje	Druge oblike študija	Samostojno delo	ECTS
45		30			75	6

Nosilec predmeta/Lecturer: Alenka Maček Lebar

Vrsta predmeta/Course type: Obvezni-strokovni /Compulsory professional

Jeziki/Languages:	Predavanja/Lectures:	Slovenščina
	Vaje/Tutorial:	Slovenščina

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

Vpis v letnik.

Prerequisites:

Enrolment in the year of the course.

Vsebina:

Načrtovanje in izvedba poskusov in meritev v medicini in biotehnologiji. Osnovni pojmi: viri biomedicinskih signalov, vrste signalov in šuma, lastnosti merilnega sistema. Fizikalne in fiziološke veličine, ki jih merimo v medicini, ter pripadajoče enote. Zanimive rešitve zaznavanja različnih signalov v naravi. Osnovni fizikalni principi senzorjev: uporovni, induktivni, kapacitivni, piezoelektrični, kemični, optični, Merjenje tlaka (neposredno in posredno merjenje, uporaba katetrskih senzorjev). Merjenje pretoka krvi in dihanja (elektromagnetne, ultrazvočne, dopplerske, pletizmografske, dilucijske in druge metode). Merjenje premikov, hitrosti, pospeška, sile in navora. Merjenje temperature, vlažnosti in pretoka toplote (kontaktno in brezkontaktno merjenje, infrardeči merilniki). Merjenje bioelektričnih potencialov (elektrokardiografija, elektroencefalografija, elektromiografija) ter bioimpedance, pojavi na elektrodah. Laboratorijske in klinične biokemijske merilne metode (pH, pO₂, plinska analiza krvi), biosenzorji. Viri in senzorji svetlobe, senzorji na osnovi optičnih vlaken, optične merilne metode (pulzna oksimetrija, laser-dopplerska metoda, bližnje-infrardeča spektroskopija itd.).

Content (Syllabus outline):

Planning and performing of experiments and measurements in medicine and biotechnology. Basic concepts: sources of biomedical signals, types of signals, noise characteristics of the measuring system. Physical and physiological quantities that are measured in medicine and related units. Interesting ways of signals acquisition in nature. The basic physical principles of sensors: resistive, inductive, capacitive, piezoelectric, chemical, optical, Measurement of pressure (direct and indirect measurements, the use of catheters). Measurement of blood flow and respiration (electromagnetic, ultrasound, Doppler, plethysmography, indicator dilution techniques and other methods). Measuring of movement, speed, acceleration, force and torque. Measurement of temperature, humidity and heat flow (contact and non-contact measurements, infrared meters). The measurement of bioelectric potentials (electrocardiography, electroencephalography, electromyography), bioimpedance, electrodes. Laboratory and clinical biochemical measuring methods (pH, pO₂, blood gas analysis), biosensors. Sources of light and light sensors, sensors based on optical fibres, optical measuring methods (pulse

	oximetry, laser-Doppler method, near-infrared spectroscopy, etc.).
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Temeljna literatura in viri/Readings:

1. Wang P, Liu Q. Biomedical Sensors and measurement. Zhejiang University Press, Springer, 201
2. Togawa T, Tamura T, Ake Oberg P. Biomedical Transducers and Instruments. CRC Press, 2011.
3. Khandpur RS. Biomedical Instrumentation: Technology and Applications. McGraw-Hill, 2004.
4. Bronzino JD (editor). The Biomedical Engineering Handbook (3rd edition). CRC Press, 2006.
5. Barth FG, Humphrey JAC, Secomb TW. Sensors and sensing in biology and engineering. Springer, 2003.

Cilji in kompetence:

Pregled fizikalnih in fizioloških veličin, ki jih najpogosteje merimo v kliničnem in raziskovalnem medicinskem okolju z velikim poudarkom na konkretnih namenih merjenja teh veličin. Spoznavanje različnih fizikalnih principov in merilnih metod ter senzorjev za merjenje teh veličin za potrebe medicinske diagnostike in raziskovalnih namenov.

Pridobitev znanja in praktičnih izkušenj za kvaliteten in varen zajem najpogostejših bioelektričnih potencialov z zajemom na površini telesa (EKG, EMG in EEG) ter različnih vrst neelektričnih bioloških signalov (na primer optične merilne metode). Pridobitev osnovnega znanja o merilnih metodah kemičnih parametrov in biosenzorjih. Praktične izkušnje z merilnimi metodami v biomedicinskem celičnem laboratoriju.

Poznavanje relativnih prednosti in omejitev obravnavanih merilnih metod s ciljem izbire najprimernejše metode za konkretni primer uporabe.

Objectives and competences:

Overview of physical and physiological variables that are most commonly measured in clinical and medical research environment with a strong focus on the specific purposes of their measurement. Understanding of the physical principles, methods of measurement as well as sensors for measuring these quantities in medical diagnostic and research.

Acquisition of knowledge and practical experience of qualitative and safe capture of the most common bioelectrical signals that can be captured on the surface of the body (ECG, EMG and EEG) and various types of nonelectric biological signals (eg. optical measurement methods). Basic knowledge of the concepts for measuring chemical parameters and biosensors. Practical experience with measuring methods in the laboratory. Knowledge of the advantages and limitations of the existing measuring methods with the aim of selecting the most appropriate method for a specific use.

Predvideni študijski rezultati:

Po uspešno opravljenem modulu naj bi bili študenti zmožni:

- opisati različne merilne metode in senzorje v medicini in biotehnologiji
- opisati nekatere pomembnejše in pogosto uporabljene merilne metode in postopke ter razložiti njihove prednosti in omejitve
- pojasniti fizikalno ozadje obravnavanih merilnih metod
- načrtovati in izvesti biomedicinske meritve tudi na drugih področjih
- kritično zagovarjati dobljene merilne rezultate.

Intended learning outcomes:

After successful completion of the course, students should be able to:

- describe various measurement methods and sensors in medicine and biotechnology
- describe some of the more important and often used measurement methods and procedures and explain their advantages and limitations
- explain the physical background of the measurement methods
- plan and perform biomedical measurements in other areas
- to critically defend the obtained measurement results.

Metode poučevanja in učenja:

Na predavanjih študenti spoznajo teoretične osnove fizikalnega ozadja obravnavanih merilnih metod in senzorjev skupaj z nameni in primeri uporabe. Seznanimo jih s postopki za pravilno načrtovanje, izvedbo in vrednotenje merilnega poskusa.

V okviru vaj študenti rokujejo s senzorji, ki so zasnovani na različnih fizikalnih principih, jih umerijo v izbranem merilnem področju in vključijo v preprost merilni sistem. Pridobijo praktične izkušnje z izvedbo nekaterih izbranih

Learning and teaching methods:

At the lectures, students learn the theoretical basis and the physical background of the existing measuring methods and sensors along with the purposes and application examples. Familiarization with the procedures for the proper planning, implementation and evaluation of the measuring experiments.

At laboratory work, students use sensors that are based on different physical principles, they calibrate them in the selected measurement regions and incorporate

neinvazivnih merilnih metod fizioloških veličin ter uporabo biokemijskih merilnih metod. Opravili bomo eno ali več ekskurzij v medicinsko ustanovo, kjer bo praktični prikaz uporabe različne biomedicinske merilne inštrumentacije.	them in a simple measurement systems. Gain hands-on experience with the implementation of some selected non-invasive methods of measurement of physiological variables and the use of biochemical measurement methods. Students attend one or more excursions to medical institutions, where practical demonstrations of the use of biomedical measurement instrumentation are held.
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Načini ocenjevanja:	Delež/Weight	Assessment:
Pisni izpit, ustni izpit, laboratorijske vaje, projekt Ocena 5 je negativna ocena, ocene od vključno 6 do 10 so pozitivne. Pozitivna ocena laboratorijskih vaj je pogoj za opravljanje izpita. Prispevki k oceni: laboratorijske vaje pisni izpit ustni izpit		Written exam, oral exam, laboratory exercises, project Negative grade is 5, positive grades: from 6 to 10. Positive evaluation of laboratory exercises is a prerequisite for the exam. Contributions to final grade: laboratory exercises written exam oral examination
laboratorijske vaje	40,00 %	laboratory exercises
pisni izpit	50,00 %	written exam
ustni izpit	10,00 %	oral examination

Reference nosilca/Lecturer's references:

1. KRAMAR Peter, MIKLAVČIČ Damijan, MAČEK LEBAR Alenka. Determination of the lipid bilayer breakdown voltage by means of linear rising signal. <i>Bioelectrochemistry</i>, 2007, 70, 1, 23-27. 2. KRAMAR Peter, MIKLAVČIČ Damijan, MAČEK LEBAR Alenka. A system for the determination of planar lipid bilayer breakdown voltage and its applications. <i>IEEE trans. nanobiosci.</i>, 2009, 8, 2, 132-138. 3. KRAMAR Peter, MIKLAVČIČ Damijan, MAČEK LEBAR Alenka. Merjenje lastnosti ravninskih lipidnih dvoslojev. <i>Elektrotehniški vestnik [Slovenska tiskana izd.]</i>, 2009, 76, 5, 293-298. 4. KRAMAR Peter, MIKLAVČIČ Damijan, KOLUTSKA Malgorzata, MAČEK LEBAR Alenka. Voltage- and current-clamp methods for determination of planar lipid bilayer properties. V: IGLIČ, Aleš (ur.). <i>Advances in planar lipid bilayers and liposomes : volume 11</i>, (Advances in planar lipid bilayers and liposomes). Amsterdam; Elsevier: Academic Press, cop. 2010, str. 29-69. 5. JELENC Jure, JELENC Jože, MIKLAVČIČ Damijan, MAČEK LEBAR Alenka. Low-frequency sonoporation in vitro : experimental system evaluation. <i>Stroj. vestn.</i>, 2012, 58, 5, 319-326.
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