

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet: Bioelektromagnetika
Course title: Bioelectromagnetics

Študijski programi in stopnja	Študijska smer	Letnik	Semestri
Elektrotehnika, druga stopnja, magistrski	Biomedicinska tehnika (smer)	2. letnik	Zimski

Univerzitetna koda predmeta/University course code: 64281

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

Nosilec predmeta/Lecturer: Tadej Kotnik

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:

Pogoj za vključitev v opravljanje študijskih obveznosti pri predmetu je vpis v 2. letnik podiplomskega študijskega programa II. stopnje Elektrotehnika na študijski smeri Biomedicinska tehnika.

Prerequisites:

A prerequisite for attending the course is the enrollment into the 2nd year of the 2nd cycle university study programme Electrical Engineering – Biomedical Engineering

Vsebina:

Elektromagnetni spekter in kratek pregled bioloških učinkov: neionizirna sevanja ter fizikalne osnove njihovih interakcij, termični učinki, netermični učinki; ionizirna sevanja in njihovi biološki učinki
Viri elektromagnetnih polj: statično magnetno polje, nizkofrekvenčna elektromagnetna polja (0-100 kHz), visokofrekvenčna elektromagnetna polja in sevanja (100 kHz-300 GHz).
Merjenje in dozimetrija: pregled merilnih metod in standardov, eksperimentalna dozimetrija, numerična dozimetrija, mikrodozimetrija.
Biološka snov v elektromagnetnem polju: statično električno in magnetno polje, nizkofrekvenčna polja (disociacija in elektrolitske raztopine, prevajanje, elektroliza in polarizacija, električne lastnosti celic in tkiv), visokofrekvenčna polja in sevanja (frekvenčna odvisnost električnih lastnosti celic in tkiv, bližnje in daljnje polje, vdorna globina, absorpcija energije, segrevanje).
Mehanizmi interakcij: električne lastnosti celic in tkiv, interakcije s šibkimi polji (mikroelektroforeza, resonančni modeli), interakcije z močnimi polji (sila na nabite delce, interakcije z vzdražnimi tkivi, termične interakcije), elektroporacija.

Content (Syllabus outline):

Electromagnetic spectrum and an overview of biological effects: non-ionizing radiation and physics of their interactions, non-thermal effects, thermal effects; ionizing radiation and its biological effects
Sources of electromagnetic fields (EMF): static magnetic field, low-frequency EMF (0-100 kHz), high-frequency EMF and radiation (100 kHz-300 GHz).
Measurements and dosimetry: an overview of measuring methods and standards, experimental dosimetry, numerical dosimetry, microdosimetry.
Biological matter in EMF: static electric and magnetic fields, low-frequency fields (dissociation and solutions, electric conductivity, electrolysis and polarization, electrical properties of cells and tissues), high-frequency fields and radiation (frequency dependence of electrical properties of cells and tissues, near and far field, penetration depth, energy absorption, heating).
Interaction mechanisms: electric properties of cells and tissues, interactions with weak fields (microelectrophoresis, resonance models), interactions with strong fields (forces on charged particles, interactions with excitable cells and tissues, thermal effects, membrane electroporation).
Overview of experimental and epidemiological studies: research in vitro, research on plants and animals in vivo,

Pregled laboratorijskih in epidemioloških raziskav: raziskave in vitro, raziskave na rastlinah in živalih in vivo, epidemiološke študije, pregled stanja raziskav v svetu. Ocena zdravstvenega tveganja, preventivni vidiki in strategija razvoja: analiza tveganj zaradi prisotnosti elektromagnetnih polj, kontrola eksperimentalnih pogojev, ponovljivost eksperimentalnih polj, načelo previdnosti, zaščita pred polji in sevanji. Uporaba električnih tokov ter elektro-magnetnih polj in sevanj v medicini: srčni spodbujevalniki in defibrilatorji, funkcionalna in protibolečinska električna stimulacija, elektroporacija, elektrokirurgija, elektrotermija. Standardi in mejne vrednosti: izhodišča, mednarodna priporočila, pravna ureditev.	epidemiological studies, current state of research and scientific position. Health risk assessment, prevention and development strategies: analysis of risks due to EMF, control of experimental conditions, reproducibility of experimental fields, precautionary principle, protection from EMF. Use of electric currents and EMF in medicine: pacemakers and defibrillators, functional and analgesic electrical stimulation, electroporation, electrosurgery, electrotherapy. Standards and exposure limits: fundamentals, international recommendations, regulations.
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Temeljna literatura in viri/Readings:

C. Furse, D. A. Christensen, C. H. Durney. *Basic Introduction to Bioelectromagnetics*, 2nd ed. CRC Press, 2009.

D. Miklavčič, P. Gajšek. *Vpliv neionizirnih elektromagnetnih sevanj na biološke sisteme*. Založba FE in FRI, 1999.

Bonner P, et al. *Establishing a dialogue on risks from electromagnetic fields*. WHO, 2002.

Adair RK. Biophysical limits on athermal effects of RF and microwave radiation. *Bioelectromagnetics* 24: 39-48, 2003.

Gajšek P (ur.). *Abstract book of the International conference on electromagnetic fields: From bioeffects to legislation*, INIS, Ljubljana, 2004.

Cilji in kompetence:

Predstaviti znanstveno utemeljene mehanizme interakcij elektromagnetnih polj in sevanj z biološkimi sistemi, predstaviti vire polj in sevanj, merjenje in dozimetrijo, pomembnejše laboratorijske in epidemiološke raziskave ter znanstveno izoblikovane mejne vrednosti.

Objectives and competences:

To describe the scientifically recognized interaction mechanisms of EMF with biological system, to present the sources of EMF, their measurements and dosimetry, the most important experimental and epidemiological studies, and scientifically based exposure limits.

Predvideni študijski rezultati:

Po uspešno opravljenem predmetu bodo študenti zmožni:

- povzeti znanstveno utemeljene mehanizme interakcij elektromagnetnih polj in sevanj z živimi organizmi;
- pojasniti teoretične osnove teh mehanizmov;
- razčleniti zdravstvena tveganja, veljavne standarde ter opozorilne in mejne vrednosti;
- uporabljati sodobne naprave in metode eksperimentalne in numerične dozimetrije;
- načrtovati in izvajati dozimetrične meritve in izračune s temi napravami in metodami;
- kritično oceniti znanstveno utemeljenost posameznih trditev in hipotez o učinkih elektromagnetnih polj in sevanj.

Intended learning outcomes:

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

- summarize the scientifically recognized mechanisms of interaction between EMF and living organisms;
- explain the theoretical basis of these mechanisms;
- elaborate on the health risks, standards, action values and exposure limits;
- use modern devices and methods in both experimental and numerical dosimetry;
- design and perform dosimetric measurements and/or computations using these devices and methods;
- assess critically the existence (or lack) of scientific basis for claims and proposed hypotheses on effects of EMF.

Metode poučevanja in učenja:

Predavanja, laboratorijske vaje za pridobivanje samostojnih praktičnih izkušenj z metodami in napravami za eksperimentalno in numerično dozimetrijo in modeliranje ter določanje električnih

Learning and teaching methods:

Lectures, laboratory work for acquisition of individual practical experience with methods and devices for experimental and numerical dosimetry and modeling, for measurements of electrical properties of biological

lastnosti bioloških tkiv, individualne seminarske naloge za seznanitev z epidemiološkimi študijami in njihovo kritično ovrednotenje.	tissues, individual seminars for improved familiarity with epidemiological studies and their critical scientific assessment.
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Načini ocenjevanja:	Delež/Weight	Assessment:
Način: laboratorijske vaje, seminar, pisni izpit, ustni izpit. Ocena 5 je negativna, ocene od vključno 6 do 10 so pozitivne. Pogoji za opravljanje izpita sta pozitivna ocena laboratorijskih vaj ($50 \leq L \leq 100$) in seminarja ($50 \leq S \leq 100$), pisni izpit pa študent opravi, če zbere vsaj polovico točk ($50 \leq P \leq 100$). V tem primeru se določi izhodišče za končno oceno (I), $I = (P + L + S)/3$, iz katerega sledi predlog končne ocene pri predmetu (K): • $90 < I \leq 100$: K = 10 • $80 \leq I \leq 90$: K = 9 • $70 \leq I < 80$: K = 8 • $60 \leq I < 70$: K = 7 • $50 \leq I < 60$: K = 6 Pri $50 \leq P < 67$ je obvezen še ustni zagovor izpita, študent pa z uspešnim zagovorom potrdi oceno K. Pri $67 \leq P \leq 100$ študent izbira med vpisom predlagane ocene K in ustnim zagovorom, s slednjim pa lahko končno oceno tako izboljša kot poslabša.		Components: lab work, seminar, written examination, oral examination. The grade 5 is negative, positive grades range from 6 to 10. The necessary condition for entering the written examination are positive grades for the lab work ($50 \leq L \leq 100$) and the seminar ($50 \leq S \leq 100$). Written exam is passed if at least half of the points are gained ($50 \leq P \leq 100$). If these requirements are met, a tentative basis for the final grade (K) is determined as follows: $I = (P + L + S)/3$, • $90 < I \leq 100$: K = 10 • $80 \leq I \leq 90$: K = 9 • $70 \leq I < 80$: K = 8 • $60 \leq I < 70$: K = 7 • $50 \leq I < 60$: K = 6 For $50 \leq P < 67$, the written exam is followed by a verbal one, and with adequate understanding the student gets grade K. For $67 \leq P \leq 100$, the student chooses between grade K and a verbal exam, where grade K can be confirmed, reduced or increased.
ocena vaj	33,33 %	grades of lab work
ocena seminarja	33,33 %	seminar and written
ocena pisnega izpita, ustni zagovor lahko oceno potrdi, izboljša ali poslabša	33,33 %	exam contribute, verbal exam can result in confirmation, reduction or increase of this grade

Reference nosilca/Lecturer's references:

1. KOS, Bor, VALIČ, Blaž, KOTNIK, Tadej, GAJŠEK, Peter. Poklicna izpostavljenost elektromagnetnim sevanjem. *Elektrotehniški vestnik*, 2010, letn. 77, št. 4, str. 200-207.
2. KOS, Bor, VALIČ, Blaž, MIKLAVČIČ, Damijan, KOTNIK, Tadej, GAJŠEK, Peter. Pre- and post-natal exposure of children to EMF generated by domestic induction cookers. *Physics in Medicine & Biology*, 2011, vol. 56, no. 19, str. 6149-6160.
3. KOS, Bor, VALIČ, Blaž, KOTNIK, Tadej, GAJŠEK, Peter. Exposure assessment in front of a multi-band base station antenna. *Bioelectromagnetics*, 2011, vol. 32, no. 3, str. 234-242.
4. KOS, Bor, VALIČ, Blaž, KOTNIK, Tadej, GAJŠEK, Peter. Occupational exposure assessment of magnetic fields generated by induction heating equipment - the role of spatial averaging. *Physics in Medicine & Biology*, 2012, vol. 57, no. 19, str. 5943-5953.
5. KOS, Bor, VALIČ, Blaž, KOTNIK, Tadej, GAJŠEK, Peter. Induced electric fields in workers near low-frequency induction heating machines. *Bioelectromagnetics*, 2014, vol. 35, no. 3, str. 222-226.