UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Analiza varnosti in tveganja v medicinski fiziki
Course title:	Evaluation of safety and risk in medical physics

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program 2.stopnje Medicinska fizika	Medicinska fizika	**1 ali 2**	**prvi ali drugi**
Second cycle academic study program Medical physics	Medical physics	**1 or 2**	**first or second**

Vrsta predmeta / Course type izbirni predmet/elective course

Univerzitetna koda predmeta / University course code:

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **work**	**Druge oblike študija**	**Samost. delo** **Individ. work**	**ECTS**
30		**15**			**75**	**4**

Nosilec predmeta / Lecturer: prof. dr. Borut Mavko

Jeziki / Languages:	**Predavanja / Lectures:**	**Slovensko/Slovene**
	Vaje / Tutorial:	**Slovensko/Slovene**

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Vpis v letnik	Regular enrolement

Vsebina: **Content (Syllabus outline):**

Osnove sevalne in jedrske varnosti Identifikacija in kvantifikacija nevarnosti Metode analize možnih nevarnosti sevalnih in jedrskih dejavnosti Človeški faktor Matematične osnove in analitična orodja Verjetnostne varnostne analize Drevesa okvar Drevesa dogodkov Deterministične varnostne analize Ocene tveganja Viri negotovosti in vrednotenje računalniških napovedi Zagotavljanje in nadzor kakovosti.	Fundamentals of radiation and nuclear safety Identification and quantification of the risks Methods of analysis of the potential hazards in radiation and nuclear activities Human factor Mathematical fundamentals and analytical tools Probabilistic safety analysis Damage decision tree Events decision tree Deterministic safety analysis Risk assessment Sources of uncertainty and evaluation of computer based predictions Quality assurance and control.

Temeljni literatura in viri / Readings:

- A.Kuhlman, Introduction to Safety Science, Springer Verlag, 1985.
- A.Kletz, HAZOP & HAZAN, Notes on the Identification and Assessment of Hazards (2nd ed.). Loss Prevention (The Institution of Chemical Engineers), Warwickshire, 1986.
- Ian S.Sutton, Process Reliability Risk Management, Van Nostrand Reinhold, 1991.
- J.S.Arendt, D.K.Lorenzo, A.F.Lusby, Evaluating Process Safety in the Chemical Industry (A Manager's Guide to Quantitative Risk Assessment), JBF Associates, Inc. New York, 1989.
- N. P.Cheremisinnoff: Practical Guide to Industrial Safety, Marcel Dekker, Inc. NY 2001

Cilji in kompetence:	**Objectives and competences:**
Seznanitev s teoretskimi determinističnimi in verjetnostnimi metodami in orodji za analizo zanesljivosti in varnosti s poudarkom na ocenjevanju tveganj sevalnih dejavnosti in optimizacijo izpostavljenosti s ciljem zmanjševanja skupnega rizika.	Students learn about deterministic and probabilistic methods for evaluation of reliability and safety in activities involving radiation, as well as for exposure optimization and minimization of risk.
Predvideni študijski rezultati:	**Intended learning outcomes:**

Znanje in razumevanje: Poznavanje teoretskih deterministični in verjetnostnih metod in orodij za analizo zanesljivosti in varnosti. **Uporaba:** Sposobnost analize zanesljivosti in varnosti jedrskih naprav. **Refleksija:** Kritično ovrednotenje teoretičnih napovedi z rezultati praktičnih meritev. **Prenosljive spretnosti - niso vezane le na en predmet:** Sposobnost zbiranja podatkov ter razlaganja in vrednotenja rezultatov.	**Knowledge and understanding:** Understanding of deterministic and probabilistic methods and tools for risk and safety assessment. **Application:** Ability to analyze the safety and reliability application of radiation facilities. **Reflection:** A critical assessment of theoretical predictions with results of measurements. **Transferable skills:** Ability to collect data, interpretation and evaluation of the results of measurements.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, seminarji, praktične vaje na reaktorju TRIGA.	Lectures, seminar, practical excercises at the TRIGA reactor.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
2 kolokvija namesto izpita iz vaj, domača naloga, izpit iz vaj, izpit iz teorije. Ocene: 1-5 (negativno), 6-10 (pozitivno) (po Statutu UL).	**50% (izpit/exam)** **50% (vaje/probl)**	2 tests with problem solving, written exam (problem solving), oral exam (questions from lectures) Marks: 1-5 (not passed), 6-10 (passed) (according to the UL rules).

Reference nosilca / Lecturer's references:

prof. dr. Borut Mavko

- BERAR, Ovidiu-Adrian, PROŠEK, Andrej, MAVKO, Borut. RELAP5 and TRACE assessment of the Achilles natural reflood experiment. Nuclear Engineering and Design, ISSN 0029-5493. [Print ed.], avg. 2013, vol. 261, str. 306-316

- URŠIČ, Mitja, LESKOVAR, Matjaž, MAVKO, Borut. Material properties' influence in fuel-coolant interaction codes. Journal of engineering for gas turbines and power, ISSN 0742-4795, 2010, vol. 132, no. 7, str. 072901-1-072901-7.
- KONČAR, Boštjan, MAVKO, Borut. Wall function approach for boiling two-phase flows. Nuclear Engineering and Design, ISSN 0029-5493. [Print ed.], 2010, vol. 240, no. 11, str. 3910-3918

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Anatomija
Course title:	Anatomy

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program 2. stopnje Medicinska fizika	Medicinska fizika	**1 ali 2**	**Prvi ali drugi**
Second cycle academic study program Medical physics	Medical physics	**1 or 2**	**First or second**

Vrsta predmeta / Course type	obvezni predmet/core course
Univerzitetna koda predmeta / University course code:	

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **work**	**Druge oblike študija**	**Samost. delo** **Individ. work**	**ECTS**
45		**15**			**120**	**6**

Nosilec predmeta / Lecturer:	Prof. dr. Dean Ravnik

Jeziki / Languages:	**Predavanja / Lectures:**	**Slovensko/Slovene**
	Vaje / Tutorial:	**Slovensko/Slovene**

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Vpis v letnik	Regular enrolement

Vsebina:	**Content (Syllabus outline):**
Lokomotorni sistem: Zgradba in osnovne značilnosti skeleta, sklepov in mišičja. Krvožilni sistem: Srce in osrčnik, arterijski, venski in mezgovni obtok. Mali, veliki in portalni krvni obtok. Dihala: Zgornje in spodnje dihalne poti, delitev pljuč, njihov krvni obtok in mezgovnice. Prsna in pljučna mrena. Prebavila: Prebavna cev, prebavne žleze. Posebnosti venske drenaže. Mezgovnice. Trebušna mrena.	Locomotor system: Structure and basic characteristics of the skeleton, joints and muscles. Circulatory system: heart and pericardium, arterial, venous and lymphatic circulation. Small, large and portal blood flow. Respiratory: Upper and lower respiratory tract, the division of lungs, their bloodstream and lymphatic vessels. Breast and lung cataract. Digestive system: Gastrointestinal tract, digestive gland. Special features of the venous

Urogenitalni sistem: Ledvice in sečna izvodila. Moški in ženski spolni aparat. Posebnosti žilja in mezgovnic v zvezi z razvojem. Retroperitonealni prostor. Živčevje: Centralno in periferno živčevje. Somatsko in vegetativno živčevje. Možganske ovojnice in likvorski sistem. Topografija: Odnosi med posameznimi sistemi in njihovimi enotami na horizontalnih in frontalnih prerezih. Tumorji: Tumorji v različnih organskih sistemih, radiološka diagnostika tumorjev (velikost, omejenost od okolice, prekrvljenost, vrsta tumorja, benignost/malignost)	drainage. Lymphatic vessels. Peritoneum. Urogenital System: kidney and urinary copies. Male and female sexual apparatus. Special features of the vasculature and lymphatic vessels in connection with the development. Retroperitoneal space. Nervous system: central and peripheral nervous system. Somatic and vegetative nervous system. Meninges and cerebrospinal fluid. Topography: Relations between individual systems and their units on the horizontal and frontal sections. Tumors: tumors in various organ systems, radiological diagnosis of tumors (size, separation from the surroundings, blood circulation, type of tumor, benignancy / malignancy)

Temeljni literatura in viri / Readings:

- Larsen WJ: Anatomy: develpoment, function, clinical correlations. Saunders, Elsevier Science, 2002, ISBN 0 - 7216 - 4646 - 8
- Moore KL: Clinically oriented anatomy. Williams & Wilkins, Baltimore, 1992 ISBN 0 - 683 - 06133 - X
- Ellis H, Logan B, Dixon A: Human cross-sectional anatomy. Atlas of body sections and CT images. Butterworth-Heinemann Ltd., Oxford, 1991, ISBN 0 7506 1241 X
- Ellis H, Logan B, Dixon A: Human sectional anatomy. Pocket atlas of body sections, CT and MRI images. Butterworth-Heinemann Ltd., Oxford, 2001, ISBN 0 34080764 4

Cilji in kompetence:	**Objectives and competences:**
Študent spozna osnove anatomije človeškega telesa. Predmetno specifične kompetence: Poznavanje in razumevanje zgradbe in delovanja posameznih sistemov v telesu s poudarkom na radioterapevtskem pristopu. Ovrednotenje in uporaba novih znanj na področju anatomije in fiziologije, predvsem s kliničnega vidika.	Students will learn about the normal body anatomy. Competences: knowledge and understanding of composition and functioning of human body systems, with some emphasis on the radiotherapeutic approach. Evaluation and application of new knowledge in the area of anatomy and physiology, in particular from the clinical point of view.
Predvideni študijski rezultati:	**Intended learning outcomes:**

Znanje in razumevanje:	**Knowledge and understanding:**
Pridobitev osnovnih znanj o glavnih sistemih človeškega telesa, njihovih medsebojnih odnosih ter delovanju. Osnovni pregled zgradbe tumorjev. **Uporaba:** Uporaba osnovnih anatomskih znanj za reševanje problemov v fizikalni medicini **Refleksija:** Kritično ovrednotenje rezultatov preiskav s teoretičnimi znanji anatomije **Prenosljive spretnosti - niso vezane le na en predmet:** Sposobnost komuniciranja s strokovnjaki medicinskih strok, identifikacija kliničnih problemov s pomočjo znanja osnov anatomije	Obtaining basic knowledge about key systems in a human body, their relationship and interactions. Overview of tumor structure. **Application:** Use of basic anatomy concepts for solving problems in physical medicine. **Reflection:** Critical evaluation of theoretical predictions in comparison to experimental results. **Transferable skills:** Ability to communicate with experts from medical fields, identification of clinical problems with the basic understanding of anatomy.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, vaje, domače naloge, konzultacije.	Lectures, problem classes, homework, consultations.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
2 kolokvija namesto izpita iz vaj, izpit iz vaj, izpit iz teorije. Ocene: 1-5 (negativno), 6-10 (pozitivno) (po Statutu UL).	**50% (izpit/exam)** **50% (vaje/probl)**	2 tests with problem solving, written exam (problem solving), oral exam (questions from lectures) Marks: 1-5 (not passed), 6-10 (passed) (according to the UL rules).

Reference nosilca / Lecturer's references:

prof. dr. Dean Ravnik, doc. dr. Marija Hribernik

- Hribernik M., Gadžijev E.M., Mlakar B., Ravnik D. Variations of Intrahepatic and Proximal

Extrahepatic Bile Ducts. Hepato-Gastroenterology 2003; 50: 342-348. ISSN 0172-6390

- Hribernik M, Gadžijev EM, Mlakar B, Ravnik D. Variations of intrahepatic and proximal extrahepatic bile ducts. Hepato-Gastroenterol, 2003; 50: 342-348. ISSN 0172-6390.
- Hribernik M, de Cecchis L, Trotovšek B, Gadžijev EM, Ravnik D. Anatomical Variations of the Right Hepatic Veins and their Relevance to Surgery. Hepato-Gastroenterol, 2003; 50: 656-660. ISSN 0172-6390.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Bioelectromagnetism
Course title:	Bioelectromagnetism

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Univerzitetni študijski program 2. stopnje Medicinska fizika	Medicinska fizika	**1 ali 2**	**Prvi ali drugi**
Second cycle academic study program Medical physics	Medical physics	**1 or 2**	**First or second**

Vrsta predmeta / Course type	izbirni predmet/elective course
Univerzitetna koda predmeta / University course code:	

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **work**	**Druge oblike študija**	**Samost. delo** **Individ. work**	**ECTS**
45		**15**			**60**	**6**

Nosilec predmeta / Lecturer:	prof. dr. Zvonko Trontelj, doc. dr. Rok Hren

Jeziki / Languages:	**Predavanja / Lectures:**	**Slovensko/Slovene**
	Vaje / Tutorial:	**Slovensko/Slovene**

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Vpis v letnik	Regular enrolement

Vsebina:	**Content (Syllabus outline):**
Uvod: električni, magnetni in elektromagnetni pojavi pri živih bitjih in pri človeku Osnove elektrofizioloških pojavov: živčna in mišična celica, električni pojavi na celični membrani, elektro fiziološke meritve na celičnem nivoju, celice v možganskem, živčnem in srčnem tkivu Bioelektrični izvori pri človeku, tkivo kot prevodnik, meritve, simulacija, modeliranje: tokovni dipol, volumski izvor, volumski prevodnik, izvor – polje, direktni in inverzni	Introduction: electric, magnetic and electromagnetic effect in live beings and humans Basics of electrophysiological effects: neural and muscle cells, electric effects on cell membrane, electrophysiological measurements on the cellular level, cells in brain, neurons and heart Bioelectrical source in humans, tissue a conductor, measurements, simulations, modeling: dipole, volume source, volume

problem za primer srca, dvo-domenski model, vpliv anizotropije Bioelektrične in biomagnetne meritve: elektroda na volumskem prevodniku, meritve bioelektričnih potencialnih razlik, biomagnetno polje, meritve biomagnetnih polj, SQUID magnetometer: enokanalna in multikanalna verzija, elektromagnetna zaščita, EKG, MKG, EEG, MEG, EMG meritve – klinične aplikacije, osnove diagnoze iz EKG in MKG meritev Električni in magnetni signali iz ostalih električno aktivnih organov: oko, prebavni trakt, pljuča Električna in magnetna stimulacija: električna stimulacija srca, defibrilacija srca, funkcionalna stimulacija nekaterih živcev Meritve električnih in magnetnih lastnosti živega tkiva: impedančne metode določanja volumna, pretok krvi v okončinah, magnetno določanje železa v nekaterih organih, meritve magnetnega onesnaženja pljuč, vloga magnetnih indikatorjev v prebavnem traktu	conductor, source – field, forward and inverse problem (example of heart), double-domain model, effect of aniosotropy Bioelectica and biomagnetic measurements: electrodes on volumetric conductor, measurements of biomelectrical potential differences, biomagnetic fields, SQUID magnetometer: one-channel and multi-channel versions, electromagnetic safety, ECG, MCG, EEG, MEG, EMG measurements – clinical applications, basic diagnosis from ECG and MCG measurements Electric and magnetic signals from other electro-active organs: eye, digestive system, lungs Electrical and magnetic stimulation: electric stimulation of the heart, heart defibrillation, functional nerve stimulation Measurements of electric and magnetic properties of neurons: impedence volumetric methods, blood flow in extremities, measurements of the magnetic lung pollution, importance of the magnetic indicators in digestive system

Temeljni literatura in viri / Readings:

- Jaakko Malmivuo, Robert Plonsey, Plonsey Malmivuo, *Bioelectromagnetism: Principles and Applications of Bioelectric and Biomagnetic Fields*, Oxford University Press; (August 1995), 512 pp, ISBN: 0195058232

Cilji in kompetence:	**Objectives and competences:**
Študenti spoznajo osnove elektrofiziološke aktivnosti električno aktivnih organov (ali delov organov) pri človeku in drugih živih bitjih. Predmetno specifične kompetence: Poznavanje in razumevanje elektrofiziologije električno aktivnih organov. Sposobnost fizikalnega opisa elektrofiziološkega delovanja organa: Modelski opis elektromagnetnega pojava. Reševanje direktnega in inverznega problema. Kritično razumevanje elektro- in magneto-fizioloških meritev in zaščite pred zunanjimi motnjami. Primerjava in analiza z relevantnimi dopolnilnimi diagnostičnimi	Students learn about the basics of electrophysiological activities of organs (or parts of organs) in human and other live beings Competences: Understanding of organ electrophysiological activities. Ability to physically describe electrophysiological activity of different organs. Modeling of the electromagnetic effects. Ability to solve forward and inverse problems. Critical understanding of electro- and magneto-physicological measurements and protection against external fields. Comparison and analysis with other diagnostic approaches.

pristopi.	

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: Pridobitev osnovnega znanja in razumevanja elektrofizioloških aktivnosti pri človeku. Znati meriti in analizirati elektrofiziološko meritev. Znati fizikalno modelirati sam pojav in uvideti povezavo z diagnostiko. **Uporaba:** Spoznati možnosti meritev elektrofiziološke aktivnosti pri človeku z namenom dopolniti diagnostične metode. **Refleksija:** Kritično ovrednotenje analize elektrofiz. meritev. Spoznanje potrebnih povezav z metodami slikanja. **Prenosljive spretnosti - niso vezane le na en predmet:** Uporaba znanj iz modelske analize in njih prenos na reševanje elektrofizioloških problemov. Znati analizirati zajete biomed. merske podatke. Sposobnost komuniciranja z zdravnikom.	**Knowledge and understanding:** Understanding of the fundamental electromagnetic concepts in humans. Being able to quantify and analyze electrophysiological measurements. Being able to model the process and connect to other diagnostic procedures. **Application:** Use of electromagnetic activity in humans as supplements to other diagnostic methods. **Reflection:** Critical evaluation of the electrophysiologic measurements. Ability to connect the knowledge to other imaging methods. **Transferable skills:** Application of the mathematical modeling skils to the electrophysiological problems. Ability to analyze the data. Ability to effectively communicate with the physicians.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, seminarji, konzultacije.	Lectures, seminars, consultations.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Izpit, vaje Ocene: 1-5 (negativno), 6-10 (pozitivno) (po Statutu UL).	**50%** **50%**	Oral exam, Written exam (problem solving) Marks: 1-5 (not passed), 6-10 (passed) (according to the UL rules).

Reference nosilca / Lecturer's references:

prof. dr. Zvonko Trontelj, doc. dr. Rok Hren

- V. Jazbinšek, R. Hren, G. Stroink, M. B. Horáček, Z. Trontelj, *Value and limitations of an inverse solution for two equivalent dipoles in localising dual accessory pathways*, Med. biol. eng. comput., vol. 41, no. 2, str. 133-140, 2003.
- R. Hren, G. Stroink, *Noninvasive characterisation of multiple ventricular events using electrocardiographic imaging,* Med. Biol. Eng. Comput., vol. 39, pp. 447-454, 2001.
- J. Pirnat, Z. Trontelj. *Correlation-based method for improvement of NQR signals utilizing signal shape information*. Appl. magn. reson., 2004, vol. 27, no. 1-2, str. 343-357.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Celična in molekularna biologija
Course title:	Cell biology and molecular biology

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Univerzitetni študijski program 2. stopnje Medicinska fizika	Medicinska fizika	**1 ali 2**	**Prvi ali drugi**
Second cycle academic study program Medical physics	Medical physics	**1 or 2**	**First or second**

Vrsta predmeta / Course type	izbirni predmet/elective course
Univerzitetna koda predmeta / University course code:	

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **work**	**Druge oblike študija**	**Samost. delo** **Individ. work**	**ECTS**
30	**15**				**105**	**6**

Nosilec predmeta / Lecturer:	prof. dr. Gregor Serša, doc. dr. Maja Čemažar

Jeziki / Languages:	**Predavanja / Lectures:**	**Slovensko/Slovene**
	Vaje / Tutorial:	**Slovensko/Slovene**

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Vpis v letnik	Regular enrolement

Vsebina:	**Content (Syllabus outline):**
Splošno o celici in načini preučevanja celice: nastanek in evolucija celic, svetlobni in elektronski mikroskop, molekularno biološke metode, prokariontska in evkariontska celica, modelni organizmi Molekularna sestava celice:voda in anorganske snovi, proteini, ogljikovi hidrati, nukleinske kisline, polisaharidi Celični metabolizem: katabolizem, anabolizem, celično dihanje, fotosinteza, encimi Zgradba in funkcija celičnih organelov: jedro;	Cells and methods of studying cells: the formation and evolution of cells, light and electron microscope, molecular biological methods, prokaryotic and eukaryotic cells, model organisms The molecular composition of cells: water and inorganic substances, proteins, carbohydrates, nucleic acids, polysaccharides Cellular metabolism : catabolism, anabolism, cellular respiration, photosynthesis, enzymes Structure and function of cell organelles:

kromosomi, geni, DNA, transkripcija, podvajanje, popravljanje in rekombinacija DNA, ribosomi in translacija, celična membrana, membranski transport, endomembranski sistem: endoplazemski retikel, Golgijev aparat, vakuole, kroženje membran; endocitoza; eksocitoza, intracelularna prebava; lizosomi, organeli energijskih transformacij: mitohondriji in kloroplasti, citosol, citoskelet: mikrotubuli, aktinski filamenti, intermediarni filamenti, celična stena Celična komunikacija: receptorji, signalne molekule Celični cikel: interfaza in M faza, regulacija celičnega cikla Celična delitev: mitoza in citokineza Celična smrt: programirana celična smrt, nekroza Mejoza in spolno razmnoževanje Osnove dedovanja Tkiva in rak: ekstracelularni matriks, medcelične povezave, obnavljanje tkiv, rak	nucleus, chromosomes, genes, DNA transcription, replication, repair and recombination of DNA, ribosomes and translation, cell membrane, membrane transport, endomembrane system: the endoplasmic Rheticus, Golgi apparatus, vacuole, circulation membranes, endocytosis, exocytosis, intracellular digestion; lysosomes, organelles of the energy transformation: mitochondria and chloroplasts, cytosol, cytoskeleton: microtubules, actin filaments, the intermediate filaments, cell wall Cellular communication: receptors, signaling molecules Cell cycle: interphase and M phase, cell cycle control Cell division: mitosis and cytokinesis Cell death: programmed cell death , necrosis Meiosis and sexual reproduction Basics of inheritance Tissues and cancer: the extracellular matrix, intercellular connections, tissue repair, cancer

Temeljni literatura in viri / Readings:

- Cooper GM. The Cell: A molecular approach. 2 izdaja, Sinauer Associates Inc, Sunderland, MA, 2000
- Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter. Molecular biology of the cell: fourth edition. Garland Publishing, Inc. New York, London, 2002.

Cilji in kompetence:	**Objectives and competences:**
Predmet je osnoven. Študent/ka nadgradi dodiplomsko znanje o temeljnih zakonitostih živega. Spozna organiziranost prokariontske in evkariontske celice. Pri evkariontski celici se seznani z molekularno strukturo in delovanjem celice. Študent/ka osvoji temeljna znanja o celični molekularni biologiji, o osnovni procesih prenosa informacije iz DNA do proteinov, o procesiranju in transportov proteinov v celicah, celičnem metabolizmu, membranskih sestojih v celic in njihovi vlogi pri prenosu informacij, o komunikaciji celic z okoljem,	Students get familiar with the basic knowledge on cell biology and molecular biology. Competences: Understanding of the cell biology, of information transfer from DNA to proteins, on the procesing and transport of proteins in the cells, cell metabolizm and communication with the environment. This knowledge will be essential in understanding related subjects, Radiobiology, Anatomy and Physiology, as well as for following and a critical evaluation of developements in the field.

razmnoževanju celic, celičnem ciklusu, smrti celic, regulaciji izražanja genov in osnovnih molekularno-bioloških metodah. Ta znanja bodo tvorila osnovo za razumevanje drugih predmetov (Radiobiologija, Anatomija, Fiziologija…), ter omogočala potrebno znanje za sledenje in kritično evaluacijo novih dognanj na tem področju.	

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: Študent/ka pozna in razume zgradbo različnih tipov celic in na njeni osnovi delovanje posameznega tipa **Uporaba:** Uporaba pridobljenih znanj o delovanju celice in metod molekularne biologije v delovnem okolju tako na raziskovalnem področju kot tudi v uporabniškem okolju. **Refleksija:** Študent je sposoben kritično ovrednotiti pridobljeno teoretično in praktično znanje o molekularni biologiji celice in ga ovrednotiti glede na specifično področje dela. **Prenosljive spretnosti - niso vezane le na en predmet:** Študent pridobi sposobnost razumevanja ostalih predmetov s tega področja in ustrezno navaja osnovno besedišče predmetnega področja kot znanstvene discipline v slovenščini in tujem jeziku (angleščini), ter je sposoben komuniciranja z ostalimi strokovnjaki s tega ali sorodnih področij.	**Knowledge and understanding:** Understanding fundamental concepts of cell structure and functioning. **Application:** Use of the understanding of cell biology and molecular biology for recognision and solving of problems in research and applications. **Reflection:** Critical evaluation of the fundamental knowledge of cell biology and molecular biology in cases of specific applications. **Transferable skills:** Ability to understand fields of science related to cell bilogy and molecular biology, and ability to effectively communicate with the experts from these fields.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, seminarji, konzultacije.	Lectures, seminars, consultations.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**

Izpit, seminarska naloga Ocene: 1-5 (negativno), 6-10 (pozitivno) (po Statutu UL).	**50%** **50%**	Oral exam, seminar Marks: 1-5 (not passed), 6-10 (passed) (according to the UL rules).

Reference nosilca / Lecturer's references:

prof. dr. Gregor Serša, doc. dr. Maja Čemažar

- Čemažar M, Grošel A, Glavač D, Kotnik V, Skoberne M, Kranjc S, Mir LM, Andre F, Opolon P, Serša G. *Effects of electrogenetherapy with p53wt combined with cisplatin on survival of human tumor cell lines with different p53 status.* DNA Cell Biol 2003; **22:** 765-75.
- Snoj M, Rudolf Z, Čemažar M, Jančar B, Serša G. *Successful sphincter-saving treatment of anorectal malignant melanoma with electrochemotherapy, local excision and adjuvant brachytherapy.* Anti-Cancer Drugs 2005; **16:** 345-8.
- TODOROVIĆ, Vesna, KAMENŠEK, Urška, SERŠA, Gregor, ČEMAŽAR, Maja. Changing electrode orientation, but not pulse polarity, increases the efficacy of gene electrotransfer to tumors in vivo. *Bioelectrochemistry*, ISSN 1567-5394. [Print ed.], 2014, vol. , no. , str. [1-9

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Eksperimentalna fizika jedra in osnovnih delcev
Course title:	Experimental nuclear and particle physics

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program 2.stopnje Medicinska fizika	Medicinska fizika	**1 ali 2**	**prvi ali drugi**
Second cycle academic study program Medical physics	Medical physics	**1 or 2**	**first or second**

Vrsta predmeta / Course type obvezni predmet/core course

Univerzitetna koda predmeta / University course code: ???

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **work**	**Druge oblike študija**	**Samost. delo** **Individ. work**	**ECTS**
30		**15**			**105**	**6**

Nosilec predmeta / Lecturer: prof. dr. Peter Križan

Jeziki / Languages:	**Predavanja / Lectures:**	**Slovensko/Slovene**
	Vaje / Tutorial:	**Slovensko/Slovene**

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Vpis v letnik	Regular enrolement

Vsebina: **Content (Syllabus outline):**

SPLOŠNI DEL	GENERAL PART
1. Prehod nabitih delcev in fotonov skozi snov. Poprečna izguba energije težkih nabitih delcev (Bethe-Blochova formula). Doseg. Sevanje Čerenkova. Prehod elektronov skozi snov. Večkratno coulombsko sipanje. Energijsko stresanje (debeli in tanki absorberji, porazdelitev Landaua). Interakcije fotonov (koherentno sipanje, fotoefekt, comptonski efekt, tvorba parov).	1 Passage of charged particles and photons through matter. Average energy loss of heavy charged particles (Bethe-Bloch formula). Range. Čerenkov radiation. Passage of electrons through matter. Coulomb multiple scattering. Energy straggling (thick and thin absorbers, Landau distribution). Interaction of photons (photoelectric effect, Compton effect, pair production) .
2. Identifikacija delcev: Meritev dE/dx pri nizkih energijah. Meritev časa preleta. Večkratno merjenje specifične ionizacije. Števci Čerenkova (pragovni detektor, Ring Imaging Čerenkov Counter – RICH). Prehodno sevanje (transition radiation). Detekcija nevtronov in nevtrinov.	2. Particle identification. Measurement of dE/ dx at low energies. Measurement of time of flight. Multiple measurements of specific ionization. Čerenkov counters (threshold detector, Ring Imaging Cherenkov Counter - RICH). Transition radiation. Detection of neutrons and neutrinos .
3. Merjenje energij: Nizkoenergijske metode za določevanje energij nabitih delcev, fotonov in nevtronov. Fano faktor. Elektromagnetni kalorimetri. Hadronski kalorimetri. Umerjanje in kontrola kalorimetrov. Atmosfera kot kalorimeter.	3 Measuring energy. Low energy methods for the determination of energies of charged particles, photons and neutrons. Fano factor . Electromagnetic calorimeters. Hadron calorimeters. Calibration and control of calorimeters . Atmosphere as a calorimeter .
POSEBNI DEL	SPECIAL SECTION
1. Polvodniški detektorji: Osnovne značilnosti polvodniških detektorjev. Čisti (intrinsic) in kompenzirani polvodniki. Dioda kot detektor sevanja. Pozicijsko-občutljivi silicijevi detektorji (konstrukcija in uporaba).	1 Solid-state detectors. Basic features of semiconductor detectors . Intrinsic and compensated semiconductors. The diode as a radiation detector. Position-sensitive silicon detectors (construction and use) .
2. Scintilacijski detektorji: Osnovne značilnosti. Organski scintilatorji (kristali, tekočine, plastiki). Anorganski kristali. Plini in stekla. Izkoristek za različne vrste sevanja. Linearnost.	2 Scintillation detectors. asic characteristics. Organic scintillators (crystals, liquids , plastic). Inorganic crystals. Gases and glass. Yielda for the various types of radiation. Linearity.
3. Ionizacijski detektorji: Mehanizem ionizacije in transport ionov in elektronov v plinih. Cilindrični proporcionalni števec. Mnogožični proporcionalni števci, načini odčitavanja signala, izkoristek. Drift komore. Time projection chamber (TPC). Tekočinski	3 Ionization detectors. Ionization mechanism and transport of ions and electrons in gases . Cylindrical proportional counter. Multiwire proportional counters, read-out, signal efficiency. Drift chamber. Time Projection

ionizacijski detektorji. 4. Elektronska obdelava signalov: Ojačevalna stopnja s transistorji. Diskriminator. Predojačevalci (napetostno, tokovno in nabojno občutljivi; izvedbe povratnih zvez). Linearni ojačevalnik s povratno zvezo. Oblikovanje sunkov (z RC, z zakasnilno linijo). Pomen izravnave pol-ničla. Obnavljanje osnovnega nivoja. Izvori šuma ter vpliv oblikovanja sunkov na razmerje signal-šum. 5. Elementi transporta žarkov nabitih delcev: Kvadrupolne leče (linearna transformacija, dublet, efektivna dolžina). Invarianca faznega prostora. Sektorski magnet s homogenim poljem. Popis transporta snopa z žarkovno elipsko (matrike in funkcija envelope).	Chamber (TPC). Liquid ionization detectors . 4 Electronic signal processing. Amplifiers with transistors. Discriminator. Preamps (voltage, current and charge sensitive; performance, feedback). Linear amplifier with feedback. Pulse shaping (with RC, with a delay line). Pole-zero cancelation. Bseline restoration. Sources of noise, impact of pulse-shaping on the signal-to-noise ratio. 5 Elements of transport for charged particle beams. Quadrupole lenses (linear transformation, doublet, effective length). Phase space invariance. Sector magnet with a homogeneous field. Beam transport in the beam elipse description (matrices and the envelope function).

Temeljni literatura in viri / Readings:

- W.R. Leo, Techniques for Nuclear and Particle Physics Experiments, Springer-Verlag, Berlin 1986.
- T. Ferbel (editor), Experimental Techniques in High-Energy Nuclear and Particle Physics**,** 2nd Edition, World Scientific 1991.
- F. Sauli (editor), Instrumentation in High Energy Physics, World Scientific 1992.
- K. Kleinknecht, Detectors for Particle Radiation, Cambridge University Press 1987.
- H. Wiedermann, Particle Accelerator Physics, Springer-Verlag 1993.
- G.F. Knoll, Radiation Detection and Measurement, J. Wiley, New York 1979 (tudi novejša izdaja).
- K.G. Steffen, High Energy Beam Optics, Interscience Publishers 1996.

Cilji in kompetence:	**Objectives and competences:**
Študent spozna osnovne metode eksperimentiranja na področju fizike jedra in osnovnih delcev. Predmetno specifične kompetence: Poznavanje in razumevanje interakcij osnovnih delcev z materiali, nastanka in zaznavanja električnih signalov, njihove obdelave in zajemanja. Poznavanje metod merjenja energije in določanja identitete. Sposobnost načrtovanja eksperimentalnih aparatur in dela z njimi.	Students learn about the basic experimental methods of nuclear and particle physics. Subject-specific competencies: Knowledge and understanding of the interaction of elementary particles with materials, formation and detection of electrical signals, their treatment and acquisition. Knowledge of methods of measurements of energy and determination of particle identity. Ability to design an experimental apparatus and to work with it.
Predvideni študijski rezultati:	**Intended learning outcomes:**

Znanje in razumevanje: Pridobitev praktičnega znanja na različnih področjih eksperimentalne fizike jedra in osnovnih delcev in astrofizike **Uporaba:** Sposobnost dela s kompleksnimi aparaturami. Razumevanje kritičnih parametrov pri poskusih na področju eksperimentalne fizike jedra in osnovnih delcev in astrofizike, sposobnost načrtovanja meritev. **Refleksija:** Kritično ovrednotenje parametrov eksperimentalnih aparatur, njihove natančnosti in zanesljivosti. **Prenosljive spretnosti - niso vezane le na en predmet:** Sposobnost dela na kompleksnih aparaturah, zajemanja podatkov in njihovega zbiranja ter analize. Sposobnost določanja natančnosti meritve.	**Knowledge and understanding:** Acquire practical knowledge in various fields of experimental nuclear physics and elementary particle and astrophysics. **Application:** Ability to work with complex experimental equipment. Understanding critical parameters in experiments in the field of nuclear physics and elementary particle and astrophysics, ability to plan new measurements. **Reflection:** A critical assessment of an experimental apparatus, its accuracy and reliability. **Transferable skills:** Ability to work on a complex apparatus, data acquisition, and its collection and analysis. Ability to determine the accuracy of the measurement.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, vaje, domače naloge, konzultacije.	Lectures, problem classes, homework, consultations.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
2 kolokvija namesto izpita iz vaj, domača naloga, izpit iz vaj, izpit iz teorije. Ocene: 1-5 (negativno), 6-10 (pozitivno) (po Statutu UL).	**50% (izpit/exam)** **50% (vaje/probl)**	2 tests with problem solving, written exam (problem solving), oral exam (questions from lectures) Marks: 1-5 (not passed), 6-10 (passed) (according to the UL rules).

Reference nosilca / Lecturer's references:

prof. dr. Peter Križan

- I. Adachi et al. [Belle Collaboration], Measurement of B- → tau- nu with a Hadronic Tagging Method Using the Full Data Sample of Belle, Phys. Rev. Lett. 110 (2013) 131801
- I. Adachi et al., Precise measurement of the CP violation parameter sin2phi_1 in B0→ c c K0 decays, Phys. Rev. Lett. 108 (2012) 171802
- P. Križan, Overview of particle identification techniques, Nucl. Instrum. Meth. A706 (2013) 48.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Fizika anatomskega slikanja
Course title:	Physics of anatomical imaging

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program 2. stopnje Medicinska fizika	Medicinska fizika	**1 ali 2**	**Prvi ali drugi**
Second cycle academic study program Medical physics	Medical physics	**1 or 2**	**First or second**

Vrsta predmeta / Course type obvezni predmet/core course

Univerzitetna koda predmeta / University course code: ???

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **work**	**Druge oblike študija**	**Samost. delo** **Individ. work**	**ECTS**
45	**15**	**15**			**105**	**6**

Nosilec predmeta / Lecturer: doc. dr. Damijan Škrk, izr. prof. dr. Igor Serša

Jeziki / Languages:	**Predavanja / Lectures:**	**Slovensko/Slovene**
	Vaje / Tutorial:	**Slovensko/Slovene**

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Vpis v letnik	Regular enrolement

Vsebina:	**Content (Syllabus outline):**
Rentgenska svetloba: viri in lastnosti rentgenske svetlobe, zgradba, delovanje, napajanje gretje, hlajenje rentgenske cevi, zaslonke, svetlobni indikatorji polja, filtri, varstvo pred ionizirajočimi sevanji Detektorji rentgenske svetlobe: nastanek in parametri radiograma, ojačevalne plasti, Bucky Potter rešetka, kontrast, povečava, razmazanost, ločljivost, šum, artefakti, zgradba, lastnosti in obdelava filma, osvetlitev, optična gostota, karakteristična	X-rays: sources and characteristics, structure, performance, heating, cooling of X-ray, apertures, light field indicators, filters, radiation safety X-ray detectors: formation and parameters of radiogram, enhancements, Bucky Potter grid, contrast, amplification, resolution, contrast, signal, noise, artifacts, radiographic film composition, properties and film development, exposure, optical density, characteristic curves, average film contrast, sensitivity, densitometer,

krivulja filma, povprečni kontrast filma, hitrostna točka, občutljivost, denzitometer, senzitometer, polprevodniški detektorji in digitalni filmi Diaskopija: sestava, vrste in delovanje diaskopskih rentgenskih aparatov, uporaba kontrastnih sredstev Fizikalni principi računalniške tomografije (CT): zgradba aparata za računalniško tomografijo, digitalni sistemi, zajem, rekonstrukcija in prikaz podatkov, CT dozni indeks, spiralni in večrezinski CT, področja uporabe CT slikanja v medicinski diagnostiki Fizikalni principi diagnostičnega ultrazvoka: izvori ultrazvočnega valovanja, prehod ultrazvočnega valovanja skozi snov, Dopplerjev pojav in ultrazvočno merjenje hitrosti pretakanja, pregled karakterističnih področij uporabe ultrazvoka v medicini Fizikalni principi slikanja z magnetno resonanco (MRI): osnove jedrske magnetne resonance, osnovni princip magnetno-resonančnega (MR) slikanja (koncept k-prostora), pregled slikovnih zaporedij za MR slikanje, oprema za MR slikanje, nevarnosti pri MR slikanju Magnetno resonančna spektroskopija v medicini: tipični MR spektri različnih jeder v bioloških sistemih, metode lokalizacije NMR signala Matematične osnove obdelave slik: operacije nad kontrastom slik, filtriranje slik (odstranjevanje šuma, ostrenje slik, iskanje robov), matematične operacije med slikami, Fouriereva transformacija, segmentiranje slik, postopki digitalne obdelave večdimenzionalnih slik, zlivanje slik Digitalni sistemi v radiologiji: predstavitev standarda DICOM, sistemi arhiviranja in pregledovanja digitalnih slik Radiološke metode v nastajanju: električna uporovna tomografija, dielektrična tomografija	sensitometers, semiconductor detectors and digital systems Diascopy: structure, types and functioning of the diascopic X-ray sources, use of contrast agents Physical principles of computed tomography (CT): scanner components, digital systems, acquisition, reconstruction and display of CT data, CT dose index, spiral CT, multislice CT, use of CT in diagnostics Physical principles of ultrasound: US sources, US propagation through materials, Doppler effects and US measurements of flow, typical use of US in diagnostics Physical principles of magnetic resonance imaging (MRI): fundamentals of NMR, fundamentals of MRI (k-space), MR acquisition sequences, MRI equipment, safety of MRI procedures Physical principles of magnetic resonance spectroscopy (MRS): typical MR spectra of different materials in biological systems, methods of NMR signal localization Image analysis: image contrast operation, image filtration (noise removal, sharpening, edge detection), mathematical operations between images, Fourier analysis, image segmentation, digital analysis of multi-dimensional images, image fusion Digital systems in radiology: DICOM standard, archival systems and overview of digital images Novel imaging techniques: electric resistance tomography, dielectric tomography

Temeljni literatura in viri / Readings:

- William R. Hendee, E. Russell Ritenour, *Medical Imaging Physics*, John Wiley & Sons, 4th

edition, (Junij 2002) 536pp, ISBN: 0471382264
- Jerrold T. Bushberg, J. Anthony Seibert, Edvin M. Leidholdt, John M. Boone, *The essential physics of medical imaging*, Lippincott Williams & Wilkins Publishers; 2nd edition (December, 2001), 933pp. ISBN: 0683301187
- Harrison H. Barrett, William Swindell, *Radiological imaging: the theory of image formation, detection and processing*, Academic Press; (September 1996), 708pp. ISBN: 0120796031
- P.P. Dendy, B. Heaton, Physics for Diagnostic Radiology , Medical Science Series, 2nd edition (1999), 446 pp ISBN 07503 0590 8
- P. Sprawls, Physical Principles of Medical Imaging, Medical Physics Publishing, (1993), 656pp, ISBN 0-944838-54-5

Cilji in kompetence:

Študent spozna fizikalno ozadje delovanja različnih aparatur za anatomsko slikanje.

Predmetno specifične komponente:
Poznavanje in razumevanje fizikalnih dejavnikov, na katerih temeljijo različne radiološke metode. Poznavanje dejavnikov, ki vplivajo na kakovost slik. Pridobitev osnovnih praktičnih znanj pri delu z diagnostičnimi slikovnimi aparaturami in spoznavanje potencialnih nevarnosti pri delu z njimi. Pridobitev osnovnih znanj digitalne obdelave slik.

Objectives and competences:

Students get familiar with the fundamentals of anatomical imaging.

Competences: Understanding of the physical fundamentals of different anatomical imaging modalities. Understanding of factors that influence image quality. Obtaining basic practical knowledge working with diagnostic equipment and understanding of potential work hazards. Obtaining basic knowledge of digital imaging analysis.

Predvideni študijski rezultati:

Znanje in razumevanje:
Študenti se seznanijo s fizikalnim ozadjem delovanja različnih aparatur za medicinsko diagnostično slikanje. Seznanili se bodo z dejavniki, ki vplivajo na kvaliteto slik in nevarnostmi pri delu ter pridobili osnovna praktična znanja pri delu z diagnostičnimi slikovnimi aparaturami.

Uporaba:
Pridobljeno znanje omogoča pravilno razumevanje dejavnikov, ki vplivajo na kakovost radioloških slik in omogoča razumevanje možnih nevarnosti pri delu z diagnostičnimi slikovnimi aparaturami.

Refleksija:
Kritično ovrednotenje kakovosti radioloških

Intended learning outcomes:

Knowledge and understanding:
Obtaining fundamental knowledge of different anatomical imaging procedures. Understanding of factors that impact image quality and obtaining fundamental knowledge of working with diagnostic imaging equipment.

Application:
Fundamental knowledge of factors that influence quality of imaging equipment will enable better application of their use, as well as understanding of potential working hazards.

Reflection:
Critical evaluation of the quality of diagnostic procedures based on theoretical predictions.

Transferable skills:

posegov na osnovi pričakovanih teoretičnih napovedi. **Prenosljive spretnosti - niso vezane le na en predmet:** Sposobnost samostojnega spremljanja novih spoznanj na področju fizike diagnostične radiologije. Kritičen odnos do standardov kakovosti in varnosti na področju fizike diagnostične radiologije.	Ability to collect the data and critically evaluate new literature in the field of anatomical imaging. Ability to understand and evaluate novel anatomical imaging procedure. Critical evaluation of existing anatomical imaging procedures.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, vaje, domače naloge, konzultacije.	Lectures, problem solving, homework, consultations.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Izpit iz teorije, izpit iz vaj, domača naloga Ocene: 1-5 (negativno), 6-10 (pozitivno) (po Statutu UL). Predmet je tudi del komisijskega izpita ob koncu študija. Ocene: opravil, ni opravil (po Statutu UL).	**50% (izpit/exam)** **50% (vaje/probl)**	Written exam (theory), written exam (problem solving), homework Marks: 1-5 (not passed), 6-10 (passed) (according to the UL rules). Subject is also a part of the final committee exam. Marks: pass/fail (according to the UL rules).

Reference nosilca / Lecturer's references:

doc. dr. Damijan Škrk, izr. prof. dr. Igor Serša

- Tratar G., Blinc A, Štrukelj M., Mikac U., Serša I. *Turbulent axially directed flow of plasma containing rt-PA promotes thrombolysis of non-occlusive whole blood clots in vitro.* Thromb. haemost., 2004, vol. 91, str. 487-496.
- BAJD, Franci, SERŠA, Igor. Mathematical modeling of blood clot fragmentation during flow-mediated thrombolysis. *Biophys. j.*, 2013, vol. 104, no. 5, str. 1181-1190
- I. Arino, et all, *The HERA-B Ring Imaging Čerenkov Counter***,** Nucl. instrum, methods phys res., Sect. A, Accel., 2003, 516, str. 445-461.
- MEKIŠ, Nejc, ŽONTAR, Dejan, ŠKRK, Damijan. The effect of breast shielding during lumbar spine radiography. *Radiol. oncol. (Ljubl.)*, mar. 2013, vol. 47, no. 1, str. 26-31, II, ilustr.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Fizika funkcionalnega in molekularnega slikanja (Medfiz)
Course title:	Physics of functional and molecular imaging

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program 2. stopnje Medicinska fizika	Medicinska fizika	**1 ali 2**	**Prvi ali drugi**
Second cycle academic study program Medical physics	Medical physics	**1 or 2**	**First or second**

Vrsta predmeta / Course type obvezni predmet/core course

Univerzitetna koda predmeta / University course code: ???

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **work**	**Druge oblike študija**	**Samost. delo** **Individ. work**	**ECTS**
45	**15**	**15**			**105**	**6**

Nosilec predmeta / Lecturer: izr. prof. dr. Marko Starič, izr. prof. dr. Robert Jeraj

Jeziki / Languages:	**Predavanja / Lectures:**	**Slovensko/Slovene**
	Vaje / Tutorial:	**Slovensko/Slovene**

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Vpis v letnik	Regular enrolement

Vsebina:	**Content (Syllabus outline):**
Osnove nuklearne medicine: namen, principi in temeljni koncepti (scintigrafija, PET, SPECT, Comptonska kamera), radioizotopi in radiofarmacevtiki, interakcija žarkov gama s snovjo. Pridobivanje radioizotopov: v jedrskem reaktorju, s ciklotronom, radioizotopski generatorji, priprava radiofarmacevtikov, kontrola kvalitete radiofarmacevtikov. Dozimetrija: notranja in zunanja dozimetrija, sistem MIRD, kinetični modeli, Monte Carlo	Basics of nuclear medicine: purpose, principles and basic concepts (scintigraphy, PET, SPECT, Compton camera), radioisotopes and radiotracers, interaction of gamma rays with matter Radioisotope production: nuclear reactors, cyclotrons, radioisotope generators, radiopharmaceutical production, quality assurance Dosimetry: internal and external dosimetry, system MIRD, kinetic models, Monte Carlo

dozimetrija Detektorji za nuklearno medicino: zahtevane lastnosti (izkoristek, pozicijska, časovna in energijska ločljivost, geometrijska akceptanca), tipi detektorjev (scintilacijski, polprevodniški in plinski), tipi scintilatorjev, števci radioaktivnost celotnega telesa. Gama kamera: osnovni princip, zgradba, komponente (scintilator, elektronika, kolimator), tipi, karakteristike (pozicijska ločljivost, izkoristek, energijska ločljivost, pogostost štetja), omejitve gama kamere (neenakomernost in nelinearnost, korekcije), karakteristike različnih vrst kolimatorjev, meritve karakteristik kamere, klinična uporaba. Kvaliteta slike: pozicijska ločljivost, kontrast, šum, metode za izvrednotenje kvalitete slike. Rekonstrukcija tomografske slike: metode na osnovi Fourierjeve dekonvolucije, iterativne metode, primerjava kvalitete slike glede na metodo. SPECT: aparature za SPECT, atenuacijski efekt in njegova korekcija, korekcija sipanja, efekt delnega volumna, karakteristike (pozicijska ločljivost, linearnost, šum ...), klinična uporaba. PET: princip, dejavniki vpliva na kvaliteto slike (doseg pozitrona, nekolinearnost fotonov, sipanje, naključne koincidence, rekonstrukcijski filtri), konstrukcija aparature za PET (različni tipi), zajem podatkov (2D in 3D način), rekonstrukcija in korekcija slike (filtri, korekcija naključnih koincidenc, sipanja in atenuacije), izračun SUV, klinična uporaba, PET/CT. Digitalno procesiranje slike: osnove, vizualizacija slike, filtriranje šuma, glajenje, detekcija robov in aktivnih volumnov	dosimetry Detectors for nuclear medicine: required characteristics (gain, positional, temporal, energy resolution, geometrical acceptance), types of detectors (scintillation, semiconductor, gas), types of scintillators, whole body counters Gamma camera: fundamental principles, components (scintillator, electronics, collimator), types, characteristics (positional resolution, gain, energy resolution, count dednsity), gamma camera limitations (non-uniformity and non-linearity, correlations), characteristics of different collimators, measurements of gamma camera characteristics, clinical application. Image quality: spatial resolution, contrast, noise, methods for image quality evaluation. Image reconstruction methods: Fourier-based deconvolution methods, iterative methods, comparison between the methods. SPECT: different types of SPECT scanners, attenuation effect and its correlations, scatter correction, partial volume correction, image characteristics (resolution, linearity, noise), clinical use. PET: fundamental principles, factors that impact image quality (positron range, co-linearity of photons, scatter, random coincidences, reconstruction filters), types of PET cameras, data acquisition in 2D and 3D, image reconstruction and image corrections (filters, random coincidences, scatter, attenuation), SUV calculation, clinical use, PET/CT Digital image processing: basics, image visualization, filtering, smoothing, edge detection, active contours

Temeljni literatura in viri / Readings:

- Simon R. Cherry, James A. Sorenson, Michael E. Phelps, *Physics in nuclear medicine*, W B Saunders; 3rd edition (July 18, 2003), 523 pp. ISBN: 072168341X
- Paul J. Early, D. Bruce Sodee, *Principles and practice of nuclear medicine*, Mosby; 2nd edition (January 15, 1995), 877 pp. ISBN: 0801625777

Cilji in kompetence:	**Objectives and competences:**

Študent spozna osnovne koncepte funkcionalnega in molekularnega slikanja, metode, pripravo aparatur, detektorje, rekonstrukcijo slike, in elemente, ki določajo kvaliteto slikanja. Predmetno specifične kompetence: Poznavanje in razumevanje metod nuklearne medicine in rekonstrukcije slike. Poznavanje dejavnikov, ki vplivajo na kakovost slik. Pridobitev osnovnih praktičnih znanj pri delu z diagnostičnimi slikovnimi aparaturami in spoznavanje potencialnih nevarnosti pri delu z njimi. Pridobitev osnovnih znanj digitalne obdelave slik.	Students get familiar with the fundamentals of functional and molecular imaging; methods, scanners, detectors, image reconstruction and elements that determine image quality. Competences: Understanding of the physical fundamentals of different nuclear medicine techniques and image reconstruction. Understanding of factors that influence image quality. Obtaining basic practical knowledge working with diagnostic equipment and understanding of potential work hazards. Obtaining basic knowledge of digital imaging analysis.
Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: Pridobitev osnovnega znanja sodobnih merskih metod v nuklearni medicini. Razumevanje vloge detektorjev in algoritmov za rekonstrukcijo slike. Seznanjanje z metodami pridobivanja izotopov za slikanje. **Uporaba:** Uporaba osnovnih fizikalnih principov za reševanje problemov v načrtovanju in izvedbi medicinskega slikanja s SPECT in PET, in v kombinaciji z drugimi metodami slikanja. **Refleksija:** Kritično ovredotenje teoretičnih napovedi z rezultati praktičnih meritev porazdelitve radioaktivnih izvorov v tkivu. **Prenosljive spretnosti - niso vezane le na en predmet:** Sposobnost zbiranja podatkov ter razlaganja in vrednotenja rezultatov. Sposobnost komuniciranja s strokovnjaki s sorodnih področij, predvsem iz medicinske stroke.	**Knowledge and understanding:** Obtaining fundamental knowledge of different procedures in nuclear medicine. Understanding the role of detectors and image reconstruction algorithms. Understanding methods for radioisotope production. **Application:** Fundamental knowledge of physica principles underlying SPECT and PET imaging in combination with other imaging methods. **Reflection:** Critical evaluation of the theoretical predictions with the experimental results of radioisotope production in tissue. **Transferable skills:** Ability to collect the data and critically evaluate new literature in the field of functional and molecular imaging. Ability to communicate with experts from similar fields, particularly medical field.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Lectures, vaje, domače naloge, konzultacije.	Lectures, problem solving, homework, consultations.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Izpit iz teorije, izpit iz vaj, domača naloga Ocene: 1-5 (negativno), 6-10 (pozitivno) (po Statutu UL). Predmet je tudi del komisijskega izpita ob koncu študija. Ocene: opravil, ni opravil (po Statutu UL).	**50% (izpit/exam)** **50% (vaje/probl)**	Written exam (theory), written exam (problem solving), homework Marks: 1-5 (not passed), 6-10 (passed) (according to the UL rules). Subject is also a part of the final committee exam. Marks: pass/fail (according to the UL rules).

Reference nosilca / Lecturer's references:

prof. dr. Marko Starič

- STARIČ, Marko, BRAČKO, Marko, GOLOB, Boštjan, KORPAR, Samo, KRIŽAN, Peter, PESTOTNIK, Rok, PETRIČ, Marko, SMERKOL, Peter, STANIČ, Samo, ZUPANC, Anže. Search for CP violation in D[sup][pm] meson decays to [phi] [pi][sup][pm]. Phys. rev. lett.. [Print ed.], 2012, vol. 108, no. 7, str. 071801-1-071801-6
- STARIČ, Marko. Track based maximum likelihood ring search algorithm. Nucl. instrum, methods phys res., Sect. A, Accel.. [Print ed.], 2008, vol. 595, no. 1, str. 237-240.

prof. dr. Robert Jeraj

- Vanderhoek, M., Perlman, S.B., and Jeraj, R., *Impact of different standardized uptake value measures on PET-based quantification of treatment response*, J Nucl Med **54**(8), 2013, 1188-94.
- Vanderhoek, M., Perlman, S.B., and Jeraj, R., *Impact of the definition of peak standardized uptake value on quantification of treatment response*, J Nucl Med **53**(1), 2012, 4-11.
- Simoncic, U. and Jeraj, R., *Cumulative input function method for linear compartmental models and spectral analysis in PET*, J Cereb Blood Flow Metab **31**(2), 2011, 750-6.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Fizika jedra in osnovnih delcev (Medfiz)
Course title:	Nuclear and particle physics

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program 2.stopnje Medicinska fizika	Medicinska fizika	**1 ali 2**	**prvi ali drugi**
Second cycle academic study program Medical physics	Medical physics	**1 or 2**	**first or second**

Vrsta predmeta / Course type obvezni predmet/core course

Univerzitetna koda predmeta / University course code: ???

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **work**	**Druge oblike študija**	**Samost. delo** **Individ. work**	**ECTS**
45		**15**			**120**	**6**

Nosilec predmeta / Lecturer: prof. dr. Peter Križan, prof. dr. Svjetlana Fajfer

Jeziki / Languages:		
	Predavanja / Lectures:	**Slovensko/Slovene**
	Vaje / Tutorial:	**Slovensko/Slovene**

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Vpis v letnik	Regular enrolement

Vsebina: **Content (Syllabus outline):**

Uvod: urejenost narave po nadstopjih. Poskusi v fiziki jedra in osnovnih delcev. Pospeševalniki. Detekcija nabitih in nevtralnih delcev. Jedrska fizika. Sile med nukleoni. Lastnosti jedra. Modeli zgradbe jeder. Standardni model. Sile na daljavo. Vrste interakcij. Barva. Simetrije in grupe. Rotacije. Clebsh-Gordonovi koeficienti. Izospin. Sipanje pip->pip. Okusna SU(3) simetrija. Mezoni. Barioni Antidelci. Nerelativistična teorija motnje, zlato pravilo. Elektrodinamika delcev brez spina. Feynmanova pravila. Sipalni presek. Razpadna širina. Diracova enacba. Rešitve Diracove enacbe za prost delec. Kovariantna oblika. Vijačnost. Diracova enacba za antidelce. Normalizacija bispinorjev. Elektrodinamika delcev s spinom 1/2. Feynmanova pravila. Moellerjevo sipanje. Vsota po spinih. Polnostna relacija. Izreki o sledeh. Sipanje e mion-> e mion. Diferencialni sipalni presek. Anihilacija e+e- ->□□, qq. Razmerje R, dokaz za obstoj barve. Kotna porazdelitev. Šibka interakcija: uvod, zgodovina. Interakcija tok-tok. Kršitev parnosti. V-A struktura. Razpad beta. Razpad miona. Razpad piona, konflikt med sučnostjo in ročnostjo. Sipanje nevtrinov. Nevtralni šibki tokovi. Šibki prehodi med generacijami, matrika CKM. Meritev matričnih elementov CKM, unitarnost. Mehanizem GIM. Nevtralni tok, ki spremeni okus. Sistem nevtralnih kaonov. Parnost P, C, CP za stanja z dvemi oz. tremi pioni. Lastna stanja CP. Kršitev CP. Škatlasti diagrami. Mešanje pri	Introduction. Experiments in particle physics, accelerators, detectors of charged and neutral particles. Nuclear physics. Force between nucleons., properties of nuclei, nuclear models. Standard Model. Elementary paricles and their interactions. Colour. Symmetries and groups. Rotations. Clebsh-Gordonovi coeficients. Isospin, pip->pip scattering. Flavour SU(3) symmetry. Mesons. Baryons. Antiparticles. Non-relativistic perturbation theory. Electrodynamics of spin-less particles. Feynman rules. Cross section, decay width. Dirac equation. Solutions for a free particle. Coariant form. Helicity. Dirac equation for anti-particles. Normalisation of bispinors. Electrodynamics of spin ½ particles. Feynman rules. Moeller scattering. Spin sum rule. Trace theorems. Scattering e mu -> e mu. Differencial cross section. Anihilation e+e- -> mu mu, qq. R ratio, proof of colour. Angular distribution. Weak interaction. History. Crrent-curent interaction. Parity violation. V-A structure. Beta decay. Mion decay. Pion decay, conflict of helicity and handedness. Neutrino scattering. Nevtral weak currents. Weak transitions between generations, CKM marix. Measurements of the CKM elements, unitarity GIM mechanism. Neutral flavour changing currents. System of neutral kaons. P, C, CP parity for states with two or three pions. Eigenstates of CP. CP violation. Box diagrams. Mixing and CP violation for neutral B mesons. Electroweak interaction. Feynmanova rules.

nevtralnih mezonih B. Kršitev CP. Elektrošibka interakcija. Feynmanova pravila. Umeritvene simetrije. Lokalna umeritev. Kovariantni odvod. Močna interakcija. Veliko poenotenje. Zveza med fiziko osnovnih delcev in razvojem vesolja	Gauge symmetries. Covariant derivative. Strong interaction. The grand unification. Relation between particle physics and cosmology.

Temeljni literatura in viri / Readings:

- F. Halzen, A.D. Martin, Quarks and Leptons, Wiley 1984
- M. Rosina, Jedrska fizika, DMFA
- D. Perkins, Introduction to High Energy Physics, Cambridge University Press 2000

Cilji in kompetence:	**Objectives and competences:**
Študent spozna osnovne zakonitosti na področju fizike jedra in osnovnih delcev. Predmetno specifične kompetence: Poznavanje in razumevanje interakcij med osnovnimi delci in med njihovimi vezanimi stanji (hadroni). Sposobnost za reševanje konkretnih problemov s področja fizike jedra in osnovnih delcev. Sposobnost povezovanja teoretičnih napovedi in meritev. Kritično ovrednotenje in uporaba novih spoznanj na področju fizike jedra in osnovnih delcev.	Students learn about the basic laws of nuclear and particle physics. Subject-specific competencies: knowledge and understanding of the interactions of elementary particles and their bound states (hadrons); the ability to solve practical problems in these areas; the ability to link the theoretical predictions and measurements; critical evaluation and application of new knowledge in the field of nuclear and particle physics.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: Pridobitev osnovnega znanja na področju fizike jedra in osnovnih delcev. Poznavanje in razumevanje interakcij med osnovnimi delci. Sposobnost povezovanja teoretičnih napovedi in meritev. Kritično ovrednotenje in uporaba novih spoznanj na področju fizike jedra in osnovnih delcev. **Uporaba:** Razumevanje interakcij med osnovnimi delci in	**Knowledge and understanding:** Acquire basic knowledge on theories and experiments in nuclear and particle physics. The ability to link the theoretical predictions and measurements. Critical assessment and application of new knowledge in the field of nuclear and particle physics. **Application:** Understanding of the laws of modern physics and applications of mathematical approaches.

interakcij med osnovnimi delci in jedri, njihov vpliv na nastanek in razvoj vesolja, stabilnost materije. Razumevanje fizikalnih osnov metod detekcije. **Refleksija:** Kritično ovredotenje teoretičnih napovedi z rezultati meritev. **Prenosljive spretnosti - niso vezane le na en predmet:** Sposobnost razumevanja pojavov ter razlaganja in vrednotenja rezultatov meritev.	**Reflection:** A critical assessment of the theoretical predictions with the results of the measurements **Transferable skills:** Ability to understand the phenomena and the interpretation and evaluation of the results of measurements

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, vaje, domače naloge, konzultacije.	Lectures, problem classes, homework, consultations.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
2 kolokvija namesto izpita iz vaj, domača naloga, izpit iz vaj, izpit iz teorije. Ocene: 1-5 (negativno), 6-10 (pozitivno) (po Statutu UL).	**50% (izpit/exam)** **50% (vaje/probl)**	2 tests with problem solving, written exam (problem solving), oral exam (questions from lectures) Marks: 1-5 (not passed), 6-10 (passed) (according to the UL rules).

Reference nosilca / Lecturer's references:

prof. dr. Peter Križan

- I. Adachi et al. [Belle Collaboration], Measurement of B- → tau- nu with a Hadronic Tagging Method Using the Full Data Sample of Belle, Phys. Rev. Lett. 110 (2013) 131801
- I. Adachi et al., Precise measurement of the CP violation parameter sin2phi_1 in B0→ c c K0 decays, Phys. Rev. Lett. 108 (2012) 171802
- P. Križan, Overview of particle identification techniques, Nucl. Instrum. Meth. A706 (2013) 48.

prof. dr. Svjetlana Fajfer

- S. Fajfer, J. F. Kamenik and I. Nišandžić, On the B → D* tau nu Sensitivity to New Physics, Phys. rev. D Part. fields gravit. cosmol. 85 (2012) 094025
- I. Doršner, S. Fajfer, J. F. Kamenik and N. Kosnik, Light colored scalars from grand unification and the forward-backward asymmetry in t t-bar production. Phys. rev. D Part. fields gravit. cosmol. 81 (2010) 055009.
- S. Fajfer, J. F. Kamenik, I. Nišandžić and J. Zupan, Implications of Lepton Flavor Universality Violations in B Decays, Phys. Rev. Lett. 109 (2012) 161801.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Fizika nevtronskih jedrskih naprav
Course title:	Physics of neutron nuclear facilities

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program 2.stopnje Medicinska fizika	Medicinska fizika	**1 ali 2**	**prvi ali drugi**
Second cycle academic study program Medical physics	Medical physics	**1 or 2**	**first or second**

Vrsta predmeta / Course type izbirni predmet/elective course

Univerzitetna koda predmeta / University course code: ???

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **work**	**Druge oblike študija**	**Samost. delo** **Individ. work**	**ECTS**
30		**15**			**75**	**4**

Nosilec predmeta / Lecturer: prof. dr. Andrej Trkov

Jeziki / Languages:	**Predavanja / Lectures:**	**Slovensko/Slovene**
	Vaje / Tutorial:	**Slovensko/Slovene**

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Vpis v letnik	Regular enrolement

Vsebina: **Content (Syllabus outline):**

Nevtroni, jedro in jedrske reakcije. Fenomenološki opis jedra, kapljični in lupinski model. Jedrske reakcije z nevtroni - direktne in preko vmesnega jedra (elastično in neelastično sipanje, radiacijsko zajetje, druge reakcije). Pregled presekov za te reakcije za pomembne nuklide. Cepitev-fenomenološki opis procesa, sproščena energija, razcepni produkti in promptni nevtroni. Promptni in zakasneli nevtroni, spekter. Pregled cepitvenih presekov za pomembne nuklide Transport nevtronov skozi snov. Transportna enačba za nevtrone, veljavnost, uporabnost, metode reševanja. Difuzijski približek, veljavnost, uporabnost, metode reševanja. Monte-Carlo metode, uporabnost, omejitve Nevtronski ščiti. Princip, tipični materiali in izvedbe. Aktivacija materiala ščita Pomnoževanje nevtronov in verižna reakcija. Princip, pomnoževalni faktor Jedrski reaktor. Princip delovanja in upravljanja z verižno reakcijo, tehnični opis tipičnega reaktorja. Vrste jedrskih reaktorjev (hitri in termični, energijski in raziskovalni). Energijska in krajevna porazdelitev nevtronov Viri nevtronov. Reaktor kot vir nevtronov. Pospeševalnik s spalacijsko tarčo. Viri na alfa-n reakcijo. Fuzijski reaktor kot vir nevtronov Metode, ki temeljijo na obsevanju z nevtroni. Izdelava medicinskih radioaktivnih izotopov (kemijska predpriprava, obsevanje, separacija, kemijsko-biološka priprava).Nevtronska terapija z borom (BNCT) - princip, opis tipične obsevalne naprave. Nevtronska radiografija (princip, opis naprave) Jedrske naprave in viri nevtronov v Sloveniji.JE Krško, raziskovalni reaktor TRIGA, Ra-Be viri. Zakoni in predpisi za delo z jedrskimi napravami	Neutrons, nucleus and nuclear reactions. Phenomenological description of the nucleus, droplet and shell models. Nuclear reactions with neutrons - direct and via an intermediate nucleus (elastic and inelastic scattering, radiative capture, other reactions). Overview of cross sections for these reactions for important nuclides. Fission, phenomenological description, energy release, decay products and prompt neutrons. Prompt and delayed neutron spectrum. Overview of fission cross-sections for important nuclides. Neutron transport in materials. Transport equation for neutrons, validity, usefulness, solving methods. Diffusion approximation to, validity, applicability, methods of solving. Monte-Carlo methods, applicability, limitations. Neutron shields. Principles, typical materials, and execution. Activation of the shield material. Multiplication of neutrons and the chain reaction. Principle, multiplication factor. Nuclear reactor. Principle of operation and control of the chain reaction,technical description of a typical reactor. Types of nuclear reactors (fast and thermal, power plants and research reactors). Energy and spatial distributions of neutrons. Sources of neutrons. Reactor as a neutron source. Accelerator with a spallation target. Neutrons from the alpha-n reaction. Fusion reactor as a source of neutrons. Methods based on the irradiation with neutrons. Production of radioactive isotopes for medical applications (chemical preconditioning irradiation, separation, chemical-biological preparation). Neutron therapy with boron (BNCT) - principle, description of the typical radiation devices. Neutron radiography (principle, description of the device).

	Nuclear facilities and sources of neutrons in Slovenia. Nuclear power plant, TRIGA research reactor, Ra-Be sources. Laws and regulations for operating nuclear facilities.

Temeljni literatura in viri / Readings:

- Rosina, Jedrska fizika
- Bell-Glasstone, Nuclear Reactor Theory, Van Nostrand, New York, 1970
- IAEA tehnični dokumenti

Cilji in kompetence:	**Objectives and competences:**
Razumevanje osnov delovanja jedrskih naprav, pri katerih se izkoriščajo nevtroni (jedrski reaktorji, obsevalne naprave za izdelavo radioaktivnih izotopov, medicinske obsevalne naprave z nevtroni, nevtronske radiografske naprave).	Students learn about the basic laws of nuclear facilities where neutrons are generated and used (nuclear reactors, irradiation facilities for isotope production and medical treatment, neutron radiography).

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: Razumevanje osnov delovanja jedrskih naprav, pri katerih se izkoriščajo nevtroni (jedrski reaktorji, obsevalne naprave za izdelavo radioaktivnih izotopov, medicinske obsevalne naprave z nevtroni, nevtronske radiografske naprave). **Uporaba:** Uporaba osnovnih fizikalnih principov za razumevanje osnov delovanja nevtronskih jedrskih naprav. **Refleksija:** Kritično ovrednotenje teoretičnih napovedi z rezultati praktičnih meritev nevtronskih tokov	**Knowledge and understanding:** Understanding the operation of neutron facilities (reactors, irradiation facilities for isotope production and medical treatment, neutron radiography). **Application:** Application of fundamental laws of physics in understanding the operation of neutron facilities. **Reflection:** A critical assessment of the theoretical predictions with the results of the measurements of neutron fluxes. **Transferable skills:**

Prenosljive spretnosti - niso vezane le na en predmet: Sposobnost zbiranja podatkov ter razlaganja in vrednotenja rezultatov.	Ability to collect data, interpretation and evaluation of the results of measurements.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, seminarji, praktične vaje na reaktorju TRIGA.	Lectures, seminar, practical excercises at the TRIGA reactor.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
2 kolokvija namesto izpita iz vaj, domača naloga, izpit iz vaj, izpit iz teorije. Ocene: 1-5 (negativno), 6-10 (pozitivno) (po Statutu UL).	**50% (izpit/exam)** **50% (vaje/probl)**	2 tests with problem solving, written exam (problem solving), oral exam (questions from lectures) Marks: 1-5 (not passed), 6-10 (passed) (according to the UL rules).

Reference nosilca / Lecturer's references:

prof. dr. Andrej Trkov

- ŽEROVNIK, Gašper, CAPOTE, R., TRKOV, Andrej. On random sampling of correlated resonance parameters with large uncertainties. Nucl. instrum, methods phys res., Sect. A, Accel.. [Print ed.], 2013, vol. 723, str. 89-98.
- ŽEROVNIK, Gašper, TRKOV, Andrej, SMITH, Donald L., CAPOTE, R. Transformation of correlation coefcients between normal and lognormal distribution and implications for nuclear applications. Nucl. instrum, methods phys res., Sect. A, Accel.. [Print ed.], 2013, vol. 727, str. 33-39. P. Križan, Overview of particle identification techniques, Nucl. Instrum. Meth. A706 (2013) 48.
- JET EFDA Contributors, SNOJ, Luka, LENGAR, Igor, ČUFAR, Aljaž, SYME, B., TRKOV, Andrej. Calculations to support JET neutron yield calibration : Modeling of the JET remote handling system. Nucl. Eng. Des.. [Print ed.], 2013, vol. 261, str. 244-250.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Fizika radioterapije
Course title:	Physics of radiotherapy

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program 2. stopnje Medicinska fizika	Medicinska fizika	**1 ali 2**	**Prvi ali drugi**
Second cycle academic study program Medical physics	Medical physics	**1 or 2**	**First or second**

Vrsta predmeta / Course type obvezni predmet/core course

Univerzitetna koda predmeta / University course code: ???

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **work**	**Druge oblike študija**	**Samost. delo** **Individ. work**	**ECTS**
45	**15**	**15**			**105**	**6**

Nosilec predmeta / Lecturer: prof. dr. Robert Jeraj

Jeziki / Languages:		
	Predavanja / Lectures:	**Slovensko/Slovene**
	Vaje / Tutorial:	**Slovensko/Slovene**

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Vpis v letnik	Regular enrolement

Vsebina:	**Content (Syllabus outline):**
Principi radioterapije: radioterapija in ostale tumorske terapije Izvori sevanja v radioterapiji: nizkoenergijski izvori, kobaltov izvor, linearni pospeševalniki, ciklotron, meritve doze, dozna kalibracija Radioterapija s fotonskimi curki: dozna porazdelitev enega curka, meritve, TAR, TMR, SAR, Burnsov zakon, Mayneordov faktor, Clarkovi integrali, zračne praznine in ostale nehomogenosti, klini, kompenzatorji Radioterapija z elektronskimi curki: dozna	Principles of radiotherapy: radiotherapy and other tumor therapies Radiation sources in radiotherapy: low energy source, Co-60 source, linear accelerators, cyclotrons, dose measurements, beam calibration Radiotherapy of photon beams: dose distribution of a single beam, measurements, TAR, TMR, SAR, Burns law, Mayneord factor, Clarks integrals, air cavities and other heteroggeneities, wedges, compensators

porazdelitev enega curka, doseg, energija, kontaminacija, meritve, popravki zaradi nehomogenosti, posebne tehnike Planiranje radioterapije: tanki fotonski curki in 3D jedra, podatki potrebni za modeliranje, prilagajanje modelov, modeliranje nestandardnih curkov, kombinacije curkov, ločna terapija, tomoterapija, specifičnosti planiranja posameznih tumorjev Brahiterapija: vrste izvorov in dozne porazdelitve, modeli izračuna doze, HDR in LDR brahiterapija, oprema za brahiterapijo Terapija s hadronskimi curki: terapija s protonskimi curki in curki težkih ionov.	Radiotherapy of electron beams: dose distribution of a single beam, range, energy, contamination, measurements, heterogeneity corrections, special techniques Treatment planning: narrow beams and 3D kernels, data necessary for modeling, model fitting, modeling of non-standard beams, beam combinations, arc therapies, tomotherapy, treatment planning specifics of different tumors Brachytherapy: sources and dose distributions, dose calculation models, HDR and LDR brachytherapy, brachytherapy equipment Hadron beam therapy: proton beam therapy and heavy ion therapy

Temeljni literatura in viri / Readings:

- Faiz M. Khan, The physics of radiation therapy, Lippincott Williams & Wilkins Publishers; 3rd edition (May 31, 2003), 650pp. ISBN: 0781730651
- Harold E. Johns and John R. Cunningham, The physics of radiology, Charles C Thomas Pub Ltd; 4th edition (December 1983), 796 pp. ISBN: 0398046697
- S. J. Karzmark and Robert J. Morton, A primer on theory and operation of linear accelerators in radiation therapy, Medical Physics Pub Corp; 2nd edition (January 1998), 50 pp. ISBN: 0944838669
- Jacob Van Dyk, The modern technology of radiation oncology, Medical Physics Pub Corp; (October 1999), 824 pp. ISBN: 094483838

Cilji in kompetence:	**Objectives and competences:**
Študent spozna osnove fizike radioterapije. Predmetno specifične kompetence: Poznavanje in razumevanje produkcije fotonskih, elektronskih in ostalih obsevalnih polj za radioterapijo ter njihovih osnovnih karakteristik. Sposobnost za reševanje konkretnih problemov s področja dozimetrije radioterapije. Sposobnost povezovanja teoretičnih napovedi in praktičnih problemov v radioterapiji. Kritično ovrednotenje in uporaba novih spoznanj na področju radioterapije (npr. nove metode obsevanja). Razvoj veščin in spretnosti v uporabi poznavanja posebnosti pri produkciji in karakteristikah sevalnih polj za radioterapijo.	Students get familiar with the radiotherapy fundamentals. Competences: Understanding of the photon, electron and other radiation therapy beam production and beam characteristics. Ability to solve concrete problems related to radiotherapy dosimetry. Ability to connect theorectical predictions with experimental data in radiotherapy. Critical evaluation and use of new advances in radiation therapy (e.g., new treatment techniques). Development of skils and techniques to understand specifics of radiation beam characteristics.

Predvideni študijski rezultati:	**Intended learning outcomes:**

Znanje in razumevanje:	**Knowledge and understanding:**
Študenti pridobijo osnovna znanja povezana z radioterapijo, se seznanijo z zunanjimi in notranjimi izvori sevanja ter spoznajo načine izračunov in meritev radioterapevtskih doz. **Uporaba:** Uporaba znanj in poznavanj osnovnih karakteristik obsevalnih polj za reševanje problemov v radioterapiji z zunanjimi in notranjimi izvori sevanja. **Refleksija:** Kritično ovrednotenje teoretičnih napovedi z rezultati praktičnih meritev sevalnih polj v radioterapiji. **Prenosljive spretnosti - niso vezane le na en predmet:** Sposobnost zbiranja podatkov in kritično ovrednotenje nove literature s področja radioterapije. Kritična analiza rezultatov pri meritvah v radioterapiji. Sposobnost komuniciranja s strokovnjaki s podobnih področij (predvsem medicinskih strok).	Obtaining basic knowledge in radiation therapy, understand external and internal radiation sources and know different types of radiation dose calculations and measurements. **Application:** Use of knowledge about fundamental characteristics of radiation treatment fields to be able to solve problems in radiation therapy with external and internal source. **Reflection:** Critical evaluation of theoretical predictions with the experimental measurements of radiation fields in radiation therapy. **Transferable skills:** Ability to collect the data and critically evaluate new literature in the field of radiation therapy. Critical evaluation of radiation therapy measurements. Ability to communicate with experts from similar fields (especially medical fields).

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, vaje, domače naloge, konzultacije.	Lectures, problem solving, homework, consultations.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Izpit iz teorije, izpit iz vaj, domača naloga Ocene: 1-5 (negativno), 6-10 (pozitivno) (po Statutu UL). Predmet je tudi del komisijskega izpita ob koncu študija. Ocene: opravil, ni opravil (po Statutu UL).	**50% (izpit/exam)** **50% (vaje/probl)**	Written exam (theory), written exam (problem solving), homework Marks: 1-5 (not passed), 6-10 (passed) (according to the UL rules). Subject is also a part of the final committee exam. Marks: pass/fail (according to the UL rules).

Reference nosilca / Lecturer's references:

prof. dr. Robert Jeraj

- Jeraj, R., Mackie, T.R., Balog, J., and Olivera, G., *Dose calibration of nonconventional treatment*

systems applied to helical tomotherapy, Med Phys 32(2), 2005, 570-7.

- Jeraj, R., Mackie, T.R., Balog, J., Olivera, G., Pearson, D., Kapatoes, J., Ruchala, K., and Reckwerdt, P., *Radiation characteristics of helical tomotherapy*, Med Phys **31**(2), 2004, 396-404.
- Jeraj, R., Wu, C., and Mackie, T.R., *Optimizer convergence and local minima errors and their clinical importance*, Phys Med Biol **48**(17), 2003, 2809-27.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Fizika sevanja in dozimetrija
Course title:	Radiation physics and dosimetry

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Magistrski študijski program 2. stopnje Medicinska fizika	Medicinska fizika	**1**	**prvi**
Second cycle academic study program Medical physics	Medical physics	**1**	**first**

Vrsta predmeta / Course type obvezni predmet/core course

Univerzitetna koda predmeta / University course code: ???

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike študija	Samost. delo Individ. work	ECTS
45		**15**			**120**	**6**

Nosilec predmeta / Lecturer: prof. dr. Marko Mikuž, doc. dr. Tomaž Podobnik

Jeziki / Languages:	**Predavanja / Lectures:**	**Slovensko/Slovene**
	Vaje / Tutorial:	**Slovensko/Slovene**

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Vpis v letnik	Regular enrolement

Vsebina:	**Content (Syllabus outline):**
Ionizirajoče sevanje: vrste in izviri ionizirajočega sevanja, osnovne količine, ki opisujejo interakcijo sevanja s snovjo (preseki, gostota toka, kerma, doza, ekspozicija) Interakcije nevtralnih delcev s snovjo: fotonske interakcije (fotoefekt, koherentno (Rayleigh) in nekoherentno (Compton) sipanje, tvorba parov, fotonuklearne reakcije), nevtronske interakcije, atenuacijski koeficienti	Ionizing radiation: sources of ionizing radiation, basic quantities that describe interactions of radiation with matter (cross sections, flux, kerma, dose, exposure) Interaction of neutral particles with matter: photon interactions (photoeffect, coherent (Rayleigh) and noncoherent (Compton) scattering, pair production, photonuclear interactions), neutron interactions, attenuation coefficients

Interakcije nabitih delcev s snovjo: elektronske interakcije (Moeller/Bhabha sipanje, zavorno sevanje, anihilacija), interakcije protonov in težjih delcev, izgube energije z ionizacijo, izgube energije s sevanjem, energijsko stresanje, enkratno in večkratno sipanje, doseg	Interactions of charged particles with matters: electron interactions (Moeller/Bhabha scattering, bremsstrahlung, annihilation), proton and ion particle interactions, energy loss, energy straggeling, single and multiple scattering, range
Radioaktivni razpad: aktivnost, razpadne konstante, razpolovni časi, ravnovesna stanja	Radioactive decay: activity, decay constants, decay times, equilibrium states
Fotonski in elektronski izvori: fluorescenca, zavorno sevanje, rentgensko sevanje, linearni pospeševalniki, filtracija	Photon and electron sources: fluorescence, bremsstrahlung, X-ray, linear accelerators, filtration
Monte Carlo simulacije: naključno vzorčenje, načini vzorčenja funkcij, Monte Carlo transport, razlika med determinističnimi in Monte Carlo izračuni, simulacije transporta nevtralnih in nabitih delcev	Monte Carlo simulations: random sampling, type of sampling, Monte Carlo transport, difference between deterministic and Monte Carlo calculations, simulations of neutral and charged particle transport
Votlinske teorije: teorija Bragg-Graya, teorija Spencer-Attixa, teorija Burlina, Fanov teorem	Cavity theories: Bragg-Gray theory, Spencer-Attix theory, Bourlin theory, Fan theorem
Osnove dozimetrije: dozimetri, absolutna in relativna dozimetrija, merilna območja, energijska odvisnost, stabilnost	Basics of dosimetry: dosimeters, absolute and relative dosimetry, measurement ranges, energy dependence, stability
Ionizacijske celice: proste ionizacijske celice, votlinske ionizacijske celice, meritve naboja in toka, saturacija in rekombinacija, ionizacija, ekscitacija in povprečna energija ionskega para	Ionization chambers: free ionization chambers, cavity ionization chambers, charge and current measurements, saturation and recombination, ionization, excitation and average energy of ion pair production
Dozimetrija in kalibracija fotonskih in elektronskih curkov z votlinskimi ionizacijskimi celicami: absolutna dozimetrija z ionizacijskimi celicami, kalibracija ionizacijskih celic, primarni standardi, kalibracija v zraku, kalibracija v fantomih,	Dosimetry and calibration of photon and electron beams using ionization chamgers: absolute dosimetry, calibration, standards, calibration in air, calibration in phantoms
Kalibracijski protokoli: kalibracija fotonskih curkov, kalibracija elektronskih curkov	Calibration protocols: photon beam calibration, electron beam calibration
Integralna dozimetrija: termoluminiscenčna dozimetrija, filmska dozimetrija, kemična dozimetrija, kalorimetrična dozimetrija,	Integral dosimetry: thermoluminescence dosimetry, flim dosimetry, chemical dosimetry, calorimetry, advantages and disadvantages of

prednosti in slabosti posameznih vrst dozimetrije Ostali detektorji sevanja: proporcionalni števci, Geiger-Muellerjevi števci, scintilacijski detektorji, polprevodniški detektorji Mikrodozimetrija: linearni prenos energije, stohastične količine	various types of dosimetry Other radiation detectors: proportional counters, Gaiger-Mueller counters, scintillation detectors, semiconductor detectors Microdosimetry: linear energy transfer, stochastic quantities

Temeljni literatura in viri / Readings:

- Frank H. Attix, *Introduction to radiological physics and radiation dosimetry*, Wiley-Interscience; (September 1986), 640pp. ISBN: 0471011460
- Glen F. Knoll, *Radiation detection and measurement*, John Wiley & Sons; 3rd edition (December 1999), 802pp. ISBN: 0471073385
- Harold E. Johns and John R. Cunningham, *The physics of radiology*, Charles C Thomas Pub Ltd; 4th edition (December 1983), 796 pp. ISBN: 0398046697
- E.B. Podgorsak (editor), *Review of Radiation Oncology Physics: A Handbook for Teachers and Students*, pp.1-532, International Atomic Energy Agency, Vienna, Austria (2004).
- E.B. Podgorsak, *Radiation Physics for Medical Physicists*, Springer, Heidelberg (2005), ISBN 3-540-25041-7

Cilji in kompetence:	**Objectives and competences:**
Cilji: Študent spozna osnovne zakonitosti na področju interakcije delcev s snovjo in dozimetrije. Predmetno specifične kompetence: Poznavanje in razumevanje fizikalnih osnov interakcije radiacije s snovjo. Poznavanje in razumevanje pomembnosti natančne dozimetrije. Sposobnost za reševanje konkretnih problemov s področja dozimetrije. Sposobnost povezovanja teoretičnih napovedi in praktičnih problemov. Kritično ovrednotenje in uporaba novih spoznanj na področju dozimetrije (npr. novi dozimetrijski protokoli). Razvoj spretnosti v uporabi poznavanja interakcij delcev s snovjo.	Objectives: Students will learn basic knowledge about particle interaction with matter and dosimetry Competences: Understanding of basic physics of particle interactions with matter. Understanding of accurate dosimetry. Ability to solve concrete dosimetry problems. Ability to connect theoretical concepts with practical examples. Critical evaluation of new knowlege in the field of dosimetry (e.g., new dosimetry protocols). Development of skills to recognize different types of interactions.
Predvideni študijski rezultati:	**Intended learning outcomes:**

Znanje in razumevanje:	**Knowledge and understanding:**
Pridobitev osnovnega znanja interakcij neposredno in posredno ionizirajočega sevanja s snovjo. Razumevanje depozicje energije ionizirajočega sevanja v snovi. Seznanjanje z osnovami dozimetričnih metod in različnimi ionizacijskimi detektorji. **Uporaba:** Uporaba osnovnih fizikalnih principov za reševanje problemov v dozimetriji, radioterapiji in slikanju z ionizirajočimi sevanji (CT, PET). **Refleksija:** Kritično ovrednotenje teoretičnih napovedi z rezultati praktičnih meritev ionizirajočega sevanja. **Prenosljive spretnosti - niso vezane le na en predmet:** Sposobnost zbiranja podatkov ter razlaganja in vrednotenja rezultatov. Sposobnost komuniciranja s strokovnjaki s podobnih področij (strojnih, elektrotehniških in medicinskih strok).	Obtaining basic knowledge of direct and indirect interaction of radiation with matter. Understanding of the energy deposition in matter. Knowing basic dosimetry methods using different ionization detectors. **Application:** Use of basic physics concepts for solving problems in dosimetry, radiotherapy and imaging using ionizing radiation (CT, PET). **Reflection:** Critical evaluation of theoretical predictions in comparison to experimental results of ionizing radiation. **Transferable skills:** Ability to collect data and explain obtained results. Ability to communicate with experts from similar fields (engineering, medical fields).

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, vaje, domače naloge, konzultacije.	Lectures, problem classes, homework, consultations.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
2 kolokvija namesto izpita iz vaj, domača naloga, izpit iz vaj, izpit iz teorije. Ocene: 1-5 (negativno), 6-10 (pozitivno) (po Statutu UL).	**50% (izpit/exam)** **50% (vaje/probl)**	2 tests with problem solving, written exam (problem solving), oral exam (questions from lectures) Marks: 1-5 (not passed), 6-10 (passed) (according to the UL rules).

Reference nosilca / Lecturer's references:

Porf. Dr. Marko Mikuž

- STUDEN, Andrej, CINDRO, Vladimir, GROŠIČAR, Borut, GRKOVSKI, Milan, MIKUŽ, Marko, ŽONTAR, Dejan. Silicon detectors for combined MRPET and MRSPECT imaging. Nucl. instrum, methods phys res., Sect. A, Accel.. [Print ed.], 2013, vol. 702, str. 88-90.
- CLINTHORNE, Neal, GRKOVSKI, Milan, GROŠIČAR, Borut, MIKUŽ, Marko, STUDEN, Andrej, ŽONTAR, Dejan. Silicon as an unconventional detector in positron emission tomography. Nucl. instrum, methods phys res., Sect. A, Accel.. [Print ed.], 2012, vol. 699, str. 216-220.
- AAD, G., CINDRO, Vladimir, DOLENC, Irena, FILIPČIČ, Andrej, FRATINA, Saša, GORIŠEK, Andrej, KERŠEVAN, Borut Paul, KRAMBERGER, Gregor, MAČEK, Boštjan, MANDIĆ, Igor, MIJOVIĆ, Liza, MIKUŽ, Marko, TYKHONOV, Andrii. Search for the Standard Model Higgs boson in the diphoton decay channel with 4.9fb[sup](-1) of pp collision data at [square root] s=7TeV with ATLAS. Phys. rev. lett.. [Print ed.], 2012, vol. 108, no. 11, str. 111803-1-111803-19

doc. dr. Tomaž Podobnik

- T. Podobnik, T. Živko, On probabilistic Parametric Inference, Journal of Statistical Planning and Inference, vol. 142, str. 3152–3166
- ABDALLAH, J., BRAČKO, Marko, GOLOB, Boštjan, KERNEL, Gabrijel, KERŠEVAN, Borut Paul, PODOBNIK, Tomaž, ZAVRTANIK, Danilo. Search for single top quark production via contact interactions at LEP2. The European physical journal. C, 2011, vol. 71, no. 2, str. 1555-1-1555-13.
- ABDALLAH, J., BRAČKO, Marko, GOLOB, Boštjan, KERNEL, Gabrijel, KERŠEVAN, Borut Paul, PODOBNIK, Tomaž, ZAVRTANIK, Danilo. Measurements of CP-conserving trilinear gauge boson couplings WWV (V [equivalent] [gamma], Z) in e[sup]+ e[sup]- collisions at LEP2. The European physical journal. C, Mar. 2010, vol. 66, issue 1/2, str. 35-56

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Fiziologija
Course title:	Physiology

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program 2. stopnje Medicinska fizika	Medicinska fizika	**1 ali 2**	**Prvi ali drugi**
Second cycle academic study program Medical physics	Medical physics	**1 or 2**	**First or second**

Vrsta predmeta / Course type	obvezni predmet/core course
Univerzitetna koda predmeta / University course code:	

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **work**	**Druge oblike študija**	**Samost. delo** **Individ. work**	**ECTS**
45		**15**			**120**	**6**

Nosilec predmeta / Lecturer:	prof. dr. Vito Starc

Jeziki / Languages:	**Predavanja / Lectures:**	**Slovensko/Slovene**
	Vaje / Tutorial:	**Slovensko/Slovene**

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Vpis v letnik	Regular enrolement

Vsebina:	**Content (Syllabus outline):**
Splošni principi: Biološki regulacijski sistemi, temeljna načela teorije sistemov, homeostaza. Transport snovi preko membran in epiteljev, transport snovi po telesu. Temelji elektrofiziologije. Temelji kontraktilnosti. Fiziologija kardiovaskularnega sistema: Električna aktivnost srca. Hemodinamika. Srce kot črpalka. Arterijski sistem. Krvni tlak in merjenje krvnega tlaka. Mikrocirkulacija. Limfni obtok. Periferna cirkulacija in njena	Basic principles: Biological regulatory systems, basic principles of system theory, homeostasis. Transport across membranes and epithelium, transport of mass in the body. Basics of electrophysiology. Basics of contractility. Physiology of cardiovascular system: Cardiac electric activity. Hemodynamics. Heart as a pump. Arterial systems. Blood pressure and measurements of blood pressure. Microcirculations. Lymphatic system. Peripheral

regulacija. Nadzor delovanja srca. Venski sistem in minutni volumen srca. Značilnosti pretoka krvi skozi posamezna področja.	circulation and regulation. Cardiac activity monitoring. Venus system and heart volume. Specifics of blood transport through various areas.
Fiziologija dihanja: Povezanost funkcije s strukturo pljuč. Alveolna ventilacija. Mehanika dihanja. Difuzija plinov v pljučih. Pretok krvi skozi pljuča. Razmerje med ventilacijo in perfuzij pljuč. Transport kisika in ogljikovega dioksida s krvjo. Uravnavanje dihanja. Nerespiratorne funkcije pljuč.	Physiology of breathing: Connection between the function and lung structure. Alveolar ventilation. Breathing mechanics. Diffusion of gasses in lungs. Blood transport through lungs. Oxygen and carbon dioxide transport in blood. Breathing control. Non-breathing functions.
Fiziologija ledvic in telesnih tekočin: Fiziologija telesnih tekočin. Fiziologija ledvic (povezanost funkcije s strukturo ledvic, ledvični krvni obtok in glomerulna filtracija, ocenjevanje mikropunkcijskih podatkov, proksimalni tubul, Henlejeva zanka in protitočnik, distalni nefron, učinki hormonov na funkcijo ledvic). Regulacija vode in elektrolitov v telesu (regulacija volumna krvi, regulacija osmolalnosti plazme, acidobazična fiziologija, homeostaza kalija).	Renal physiology and body liquids: Physiology of body liquids. Renal physiology (connection between the kidney function and structure, renal blood circulation and glomeral filtrations, estimation of microbiopsy data, proximal tubul, Henley's loop, distal nephron, hormone effects on kidney function). Regulation of water and electrolytes in the body (blood regulation, osmotric regulation, acido-basis physiology, kalium homeostasis).
Fiziologija živčne celice in sinaptični prenos: Mikrofiziologija sinaptičnega prenosa, mediatorski sistemi, regeneracija živčne celice.	Physiology of neural cell and synaptic transfer: Microphysiology of synaptic transfer, mediator systems, neural cell regeneration.
Fiziologija nevronskih sklopov: Značilni pojavi v mreži nevronov. Refleksi. Razvoj živčevja.	Physiology of neural networks: Characteristics of neural networks. Reflex. Neural network development.
Pregled funkcijskih enot živčnega sistema: Senzorični sistemi (senzorični procesi - splošno, somatosenzorični, posebej bolečina, vidni, slušni, vestibularni sistem, voh in okušanje). Motorični sistem (hrbtenjača, možgansko deblo, primarni in neprimarni motorični korteks, bazalni gangliji, mali možgani). Retikularna formacija. Vegetativni živčni sistem. Hipotalamus. Nevroendokrinologija. Limbični sistem.	Overview of neural system: Sensory systems (general sensory processes, somatosensory processes, especially pain, visual, audio and vestibular system, smell and taste). Motor systems (spinal cord, brainstem, primary and secondary motor cortex, basal ganglia, brain). Reticular formation. Vegetative neural system. Hypothalamus. Neuroendocrinology. Lymbic system.
Senzorično - motorična integracija: Hrbtenjačni nivo (refleksi, lokomocija). Nivo možganskega debla (posturalni refleksi, nadzor	Sensory-motor integration: Spinal cord level (reflex, locomotory signaling). Brainstem level (postural reflex, eye motion control). Cortical level (motion, language control). Higher neural

očesnih gibov). Kortikalni nivo (nadzor gibanja, govor). Nevroanatomski substrat višjih živčnih dejavnosti. Elektrofiziologija kortikalnih celic (EEG). Budnost, spanje. Motivacija. Čustvovanje. Specializacija možganskih polobel. Pomnenje in učenje. Fiziologija prebave: Fiziologija gladke mišice in motiliteta prebavil. Prebavni encimi in sokovi, fiziologija sekrecije in absorpcije. Metabolizem: Izmenjava energije. Energijska bilanca. Termoregulacija. Povezave v metabolizmu. Posebnosti metabolizma v posameznih organih in tkivih. Metabolizem kalcija in fiziologija kosti. Metabolizem železa in oligoelementov. Fiziologija endokrine sekrecije: Fiziologija hormonske sekrecije, učinki in mehanizmi delovanja hormonov (hipofiza in hipotalamus, ščitnica, nadledvična žleza, spolne žleze). Fiziologija nosečnosti: Integracija telesnih funkcij: telesni napor, ortostaza.	functions. Electrophysiology of higher neural functions. Electrophysiology of cortical cells. Sleeping and awake states. Motivation. Emotions. Specialization of brain hemispheres. Memory and learning. Physiology of digestive system: Physiology of smooth muscles and digestive functions. Digestive enzymes. Physiology of secretion and absorption. Metabolism: Energy balance. Thermo-regulation. Connections in metabolism. Specific of metabolism in different organs and tissues. Metabolism of calcium and bone physiology. Metabolism of iron and oligoelements. Physiology of endocrine secretion: Physiology of hormonal secretion, effects and mechanisms of hormone regulations (hypothalamus, thyroid, adrenal gland, ovaries and testes). Physiology of pregnancy: Integration of body functions: body effort, ortostasis.

Temeljni literatura in viri / Readings:

- Berne RM, Levy MN, Koeppen BM in Stanton BA. Physiology, 5th Ed. St.Louis: Mosby, 2004

Cilji in kompetence:	**Objectives and competences:**
Študent se spozna s funkcijo normalnega organizma. Usvoji temeljne koncepte v fiziologiji in spozna principe merjenja fizioloških pojavov ter se navaja v skladu s koncepti interpretirati rezultate meritev. Pouk fiziologije temelji na uporabi pridobljenih spoznanj iz biofizike, biokemije, biologije in normalne morfologije.	Students will learn about the normal body physiology. They will understand fundamental concepts in physiology and principles of physiologic measurements. They will be able to present the results of the measurements in the context of basic physiologic concepts. Basic understanding of biophysics, biochemistry, biology and normal morphology will be developed.
Predvideni študijski rezultati:	**Intended learning outcomes:**

Znanje in razumevanje: Pridobitev osnovnih znanj o glavnih sistemih človeškega telesa, njihovih medsebojnih odnosih ter delovanju. **Uporaba:** Uporaba osnovnih fizioloških znanj za reševanje problemov v fizikalni medicini **Refleksija:** Kritično ovrednotenje rezultatov preiskav s teoretičnimi znanji fiziologije **Prenosljive spretnosti - niso vezane le na en predmet:** Sposobnost komuniciranja s strokovnjaki medicinskih strok, identifikacija kliničnih problemov s pomočjo znanja osnov fiziologije	**Knowledge and understanding:** Obtaining basic knowledge about key systems in a human body, their relationship and interactions. **Application:** Use of basic physiological concepts for solving problems in physical medicine. **Reflection:** Critical evaluation of theoretical predictions in comparison to experimental results. **Transferable skills:** Ability to communicate with experts from medical fields, identification of clinical problems with the basic understanding of physiology.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, vaje, domače naloge, konzultacije.	Lectures, problem classes, homework, consultations.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
2 kolokvija namesto izpita iz vaj, domača naloga, izpit iz vaj, izpit iz teorije. Ocene: 1-5 (negativno), 6-10 (pozitivno) (po Statutu UL).	**50% (izpit/exam)** **50% (vaje/probl)**	2 tests with problem solving, written exam (problem solving), oral exam (questions from lectures) Marks: 1-5 (not passed), 6-10 (passed) (according to the UL rules).

Reference nosilca / Lecturer's references:

prof. dr. Vito Starc

- SAKOWSKI, Chris, STARC, Vito, SMITH, Scott M., SCHLEGEL, Todd T. Sedentary long-duration head-down bed rest and ECG repolarization heterogeneity. Aviation space and environmental

medicine, ISSN 0095-6562, 2011, vol. 82, issue 4, str. 416-423.

- SCHLEGEL, Todd T., KULECZ, Walter B, STARC, Vito, VRTOVEC, Bojan, et al. Accuracy of advanced versus strictly conventional 12-lead ECG for detection and screening of coronary artery disease, left ventricular hypertrophy and left ventricular systolic dysfunction. BMC cardiovascular disorders, ISSN 1471-2261, 2010, letn. 10, str. 28 [1-11]
- KIRN, Borut, STARC, Vito. Continuous axial contraction wave in the free wall of the guinea pig left ventricle. Comput. biol. med.. [Print ed.], 2007, letn. 37, št. 10, str. 1394-1397.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Izbrana poglavja iz fizike
Course title:	Selected topics in physics

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program 2. stopnje Medicinska fizika	Medicinska fizika	**1 ali 2**	**Prvi ali drugi**
Second cycle academic study program Medical physics	Medical physics	**1 or 2**	**First or second**

Vrsta predmeta / Course type izbirni predmet/elective course

Univerzitetna koda predmeta / University course code: ???

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **work**	**Druge oblike študija**	**Samost. delo** **Individ. work**	**ECTS**
	60				**30**	**3**

Nosilec predmeta / Lecturer: prof. dr. Slobodan Žumer

Jeziki / Languages:	
Predavanja / Lectures:	**Slovensko/Slovene**
Vaje / Tutorial:	**Slovensko/Slovene**

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Vpis v letnik	Regular enrolement

Vsebina:	**Content (Syllabus outline):**
Program predavanj se oblikuje vsako leto, delno – približno v polovici primerov – prispevajo predavanja gostje iz tujine, delno pa pokriva raziskovalne novosti iz področij fizike, ki se raziskovalno gojijo na FMF in v sorodnih raziskovalnih institucijah.	The content is determined each year, according to the availability of guest lecturers (roughly half of the seminars) and researchers from the department and neighbouring institutions.

Temeljni literatura in viri / Readings:

- Vezana na konkreten program predavanj, se oblikuje sproti.
- Related to the concrete set of lectures and seminars, is determined according to the

needs.

Cilji in kompetence:	Objectives and competences:
Študenti se pri predmetu seznanijo z najnovejšimi raziskovalnimi spoznanji na širšem področju fizike.	Students gain a broad knowledge on the recent progress in physics in general.

Predvideni študijski rezultati:	Intended learning outcomes:
Znanje in razumevanje: Poznavanje novosti na širšem področju fizike. **Uporaba:** Prenos spoznanj iz enega področja fizika na drugo. Sodelovanje v znanstvenih diskusijah. **Refleksija:** Kritično presojanje podatkov v literaturi, kritično presojanje predavanj drugih predavateljev. **Prenosljive spretnosti - niso vezane le na en predmet:** Sodelovanje v diskusiji.	**Knowledge and understanding:** Obtaining a broad knowledge in physics. **Application:** Transfer of the knowledge and experience between variuos areas in physics. Taking part in scientific discussions. **Reflection:** Critical assessment of the data found in the literature. Critical evaluation of lecturers. **Transferable skills:** Taking part in a discussion

Metode poučevanja in učenja:	Learning and teaching methods:
Predavanja.	Lectures.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	Assessment:
Obisk predavanj	**100%**	Attending the lectures.

Reference nosilca / Lecturer's references:

prof. dr. Slobodan Žumer

- D. Svenšek and S. Žumer, *Hydrodynamics of pair-annihilating disclinations in SmC films,* Phys. Rev. Lett. 90, 155501 (2003)
- T. Jin, G. P. Crawford, R. J. Crawford, S. Žumer, and D. Finotello, *Surface ordering transitions at a liquid crystal-solid interface above the isotropic smectic A transition,* Phys. Rev. Lett. 90, 015504 (2003)
- K. Kočevar, A. Borstnik, I. Muševič, and S. Žumer, *Capillary condensation of a nematic liquid crystal observed by force microscopy,* Phys. Rev. Lett. **86**, 5914 (2001)

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Klinični vidiki diagnostike in terapije
Course title:	Clinical aspects of diagnostic imaging and therapy

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program 2. stopnje Medicinska fizika	Medicinska fizika	**1 ali 2**	**Prvi ali drugi**
Second cycle academic study program Medical physics	Medical physics	**1 or 2**	**First or second**

Vrsta predmeta / Course type izbirni predmet/elective course

Univerzitetna koda predmeta / University course code: ???

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **work**	**Druge oblike študija**	**Samost. delo** **Individ. work**	**ECTS**
45	**30**				**105**	**6**

Nosilec predmeta / Lecturer: prof. dr. Primož Strojan

Jeziki / Languages:		
	Predavanja / Lectures:	**Slovensko/Slovene**
	Vaje / Tutorial:	**Slovensko/Slovene**

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Vpis v letnik	Regular enrolement

Vsebina:	**Content (Syllabus outline):**
Terapija *Priprava bolnika na obsevanje:* izbor in seznanjanje bolnikov z radioterapijo kot načinom zdravljenja raka; namen in vrste obsevanja – paliativen, radikalen; tele-brahiradioterapija; pozicioniranje bolnika – namen, pripomočki; simulacija obsevanja – namen, vrste (klasična, virtualna), praktična izvedba;	***Therapy*** *Preparation of patients for radiotherapy:* choice of patients and consultation, purpose and types of radiotherapy – palliation, radical RT, tele-brachytherapy, patient positioning – purpose, tools, simulation – purpose, types (classical, virtual), practical aspects *Treatment planning:* spatial information – purpose, types (historical overview), need for

*Načrtovanje obsevanja:*prostorska informacija – pomen, načini pridobivanja (zgodovinski pregled), obdelava za potrebe načrtovanja obsevanja; ICRU priporočila; načrtovanje obsevanja – zahteve, vrste (2D, 2.5D, 3D), možnosti in omejitve; *Izvajanje obsevanja:*kontrola lege obsevalnih polj – namen, načini (tehnične možnosti), natančnost; kontrola obsevalne doze – namen, načini merjenja (prednosti, slabosti); *Obsevalna poškodba:* radiobiologija tumorjev in zdravih tkiv; značilnosti učinkovanja fotonov in elektronov na tkivo; tolerančne doze za posamezna tkiva; mehanizmi nastanka obsevalne poškodbe in klinične manifestacije; *Izbrani primeri iz klinične praks:*priprava in načrtovanje obsevanja bolnika s tumorjem ORL področja; priprava in načrtovanje obsevanja bolnika s tumorjem pljuč; priprava in načrtovanje obsevanja bolnika s tumorjem danke; priprava in načrtovanje obsevanja bolnice s tumorjem maternicnega vratu; *Stereotaktično obsevanje* (stereotaktična radiokirurgija, stereotaktična radioterapija) *Intenziteto modulirajoča radioterapija (IMRT)* *Slikovno-vodena radioterapija (IGRT)* ***Slikanje*** *Ultrazvok*: klinične indikacije, osnovni UZ znaki pri najpogostejših patoloških procesih, prednosti in pomanjkljivosti UZ tehnologije. *CT*: klinične indikacije, osnovni CT znaki pri najpogostejših patoloških procesih, prednosti in pomanjkljivosti CT tehnologije. *MRI*: klinične indikacije, osnovni MRT znaki pri najpogostejših patoloških procesih, prednosti in pomanjkljivosti MRT tehnologije.	treatment planning, ICRU recommendations, types of treatment planning (2D, 2.5D, 3D), possibilities and limitations *Radiotherapy:* treatment beam verification – purpose, types (technical feasibility), dose verification – purpose, types of measurements (advantages, disadvantages) *Radiation damage:* radiobiology of tumors and normal tissues, principles of photon and electron radiation damage, tolerance doses for different tissues, mechanisms of radiation damage and clinical manifestations *Selected cases from clinical practice:* preparation of the patients with head and neck, lung, colorectal, cervix, and brain tumors *Stereotaxic radiation therapy (SRS and SRT)* *Intensity modulated radiation therapy (IMRT)* *Image-guided radiation therapy (IGRT)* ***Imaging*** *Ultrasound:* clinical indications, US images of most common pathological processes, advantages and disadvantages of US technologies *CT:* clinical indications, CT images of most common pathological processes, advantages and disadvantages of CT technologies *MRI:* clinical indications, MRI images of most common pathological processes, advantages and disadvantages of MRI technologies *Nuclear medicine and PET:* clinical indications, nuclear medicine/PET images of most common pathological processes, advantages and disadvantages of nuclear medicine/PET technologies

Nuklearna medicina in PET: klinične indikacije osnovni PET znaki pri najpogostejših patoloških proces, prednosti in pomankljivosti nuklearne medicine in PET	

Temeljni literatura in viri / Readings:

- Perez CA, Luther WB. Principles and practice of radiation oncology. 4th ed. JB Lippincott: Philadelphia, 2003.
- Khan FM, Potish RA. Treatment planning in radiation oncology. Williams & Wilkins: Baltimore, 1998.
- Valk P.E., Bailey D.E., Townsend D.W., Maisey M.N.: Positron emission tomography. Springer Verlag; London, Heidelberg, New York, 2003
- Murray I.P.C. and ELL P. EDS. Nuclear medicine in clinical diagnosis and treatment. 2nd ed. Churchill Livingstone, Edinburgh, 1998.
- David Sutton, Textbook of Radiology Imaging. Churchill Livingstone: New York, Edinburgh, London (last edition).

Cilji in kompetence:	**Objectives and competences:**
Študent spozna teoretične osnove radioterapije in slikanja kot zdravstvene stroke. Predmetno specifične kompetence: Poznavanje in razumevanje kriterijev izbora bolnikov za zdravljenje z obsevanjem, postopka priprave bolnika na obsevanje, izvajanje samega obesevanja in evaluacija kvalitete izvedenega obsevanja; poznavanje konvencionalnih in sodobnih obsevalnih tehnik. Poznavanje izbora različnih slikovnih tehnik (UZ, CT, MRI, nuklearna medicina/PET).	Students get familiar with the theoretical basis of therapy and imaging as health care disciplines. Competences: Understanding of the criteria of patient selection for radiotherapy, procedure of patient preparation for radiotherapy, radiotherapy itself, and treatment verification; understanding of the conventional and advanced radiotherapy techniques. Understanding of selection of various imaging techniques (US, CT, MRI, nuclear medicine/PET).

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: Študenti se seznanijo s tistimi deli postopka diagnostike in terapije, predvsem priprave, načrtovanja in izvedbe obsevanja, kjer je ključno sodelovanje med zdravnikom-radioterapevtom in radiofizikom. Podane so medicinske, radiobiološke in radiofizikalne osnove, nujne za razumevanje izdelave obsevalnega načrta, kot ključne točke	**Knowledge and understanding:** Students get familiar with the procedures of diagnostics and therapy, especially patient prepration, planning and therapy itself, where the collaboration between physicans and physicists is essential. Understanding of the medical, radiobiological and radiophysical basis, essential for development of treatment plan, as the key process of the inter-disciplinary

omenjenega sodelovanja. **Uporaba:** Poznavanje osnovnih postopkov v klinični diagnostiki in radioterapiji (obsevanju bolnikov). **Refleksija:** Kritično vrednostenje kvalitete postopkov povezanih z diangostiko in obsevanjem bolnikov. **Prenosljive spretnosti - niso vezane le na en predmet:** Sposobnost kritično vrednostenje literature s področja klinične diagnostike in radioterapije; identifikacija in reševanje problemov v klinični diagnostiki in radioterapiji; sposobnost komunikacije s strokovnjaki sodrodnih medicinskih področij.	collaboration. **Application:** Understanding of key imaging and radiotherapeutic procedures **Reflection:** Critical assessment of quality of imaging and therapeutic procedures . **Transferable skills:** Ability of critical evaluation of imaging and therapeutic literature; identification and solving of the imaging and therapeutic problems; ability to communicate effectively with the experts from a related medical fields.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, seminarji, konzultacije.	Lectures, seminars, consultations.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Izpit, seminarska naloga Ocene: 1-5 (negativno), 6-10 (pozitivno) (po Statutu UL).	**50% (izpit/exam)** **50% (seminar)**	Oral exam, seminar Marks: 1-5 (not passed), 6-10 (passed) (according to the UL rules).

Reference nosilca / Lecturer's references:

prof. dr. Primož Strojan

- TAKES, Robert P., STROJAN, Primož. The controversy in the management of the N0 neck for squamous cell carcinoma of the maxillary sinus. Eur. arch. oto-rhino-laryngol., 2013, 6 str., doi: 10.1007/s00405-013-2591-0.
- STROJAN, Primož, GRAŠIČ-KUHAR, Cvetka, ŽUMER, Barbara, KADIVEC, Maksimiljan, KARNER, Katarina Barbara, FAJDIGA, Igor, JANČAR, Boris, GALE, Nina, POLJAK, Mario, KOCJAN, Boštjan, ZAKOTNIK, Branko. TPF induction chemotherapy and concomitant irradiation with cisplatin and cetuximab in unresectable squamous cell carcinoma of the head and neck. Head Neck, 2013, vol. , no. , str., doi: 10.1002/hed.23506
- Strojan P, Šoba E, Lamovec J, Munda A. *Extramedullary plasmacytoma: clinical and histopathologic study.* Int J Radiat Oncol Biol Phys 2002; 53: 692-701.
- Šmid L, Budihna M, Zakotnik B, Šoba E, Strojan P, Fajdiga I, Žargi M, Oblak I, Dremelj M, Lešničar H. *Postoperative concomitant irradiation and chemotherapy with mitomycin C and*

bleomycin for advanced head and neck carcinoma. Int J Radiat Oncol Biol Phys 2003; 56: 1055-1062.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Modelska analiza 1
Course title:	Model analysis 1

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Magistrski študijski program 2.stopnje Medicinska fizika	vse	**1**	**prvi**
Second cycle academic study program Medical physics	all	**1**	**first**

Vrsta predmeta / Course type obvezni predmet/core course

Univerzitetna koda predmeta / University course code: ???

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike študija	Samost. delo Individ. work	ECTS
30		**30**			**120**	**6**

Nosilec predmeta / Lecturer: prof. dr. Alojz Kodre

Jeziki / Languages:	**Predavanja / Lectures:**	**Slovensko/Slovene**
	Vaje / Tutorial:	**Slovensko/Slovene**

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Vpis v letnik	Regular enrolement

Vsebina: **Content (Syllabus outline):**

Kinematični modeli (variacijski pristop, linearno programiranje, nelinearna minimizacija). Populacijski modeli in modeli kemijske kinetike (fazna analiza, modeliranje podatkov in ocena parametrov, metoda normalne matrike, metoda z razcepom po singularnih vrednostih), Stohastični modeli (generatorji slučajnih števil, osnovne modelske verjetnostne porazdelitve, integracija Monte Carlo, simulacije, Metropolisov algoritem), Harmonska analiza (FFT, konvolucija, filtriranje podatkov, rekonstrukcija zašumljenih podatkov).	Kinematic models (variational approach, linear programming, nonlinear minimization). Population models and chemical kinetics (phase analysis, data modeling and estimation of parameters, the method of normal matrix, singular decomposition method). Stochastic models (random number generators, basic model probability distribution, Monte Carlo integration, simulation, Metropolis algorithm). Harmonic analysis (FFT, convolution, filtering of data, reconstruction of noisy data).

Temeljni literatura in viri / Readings:

- I. Kuščer, A. Kodre: Matematične metode v fiziki in tehniki, DMFA, Ljubljana 1994,
- W.H. Press, B.P.Flannery, S.A.Teukolsky, W.T.Vetterling: Numerical Recipes, Cambridge Univ. Press, 1986,
- J.W. Demmel: Uporabna numerična linearna algebra, DMFA, Ljubljana 2000,
- M.H.Kalos, P.A.Whitlock: Monte Carlo methods.

Cilji in kompetence:	**Objectives and competences:**
Seznanitev z osnovnimi modelskimi pristopi in usvojitev osnovnih matematičnih orodij modeliranja. Vsaka tedenska enota je kombinacija modelske vsebine in matematičnega orodja.	Understanding of fundamental model-based approaches and basic mathematical modeling tools. Each weekly unit is a combination of a model and mathematical tools.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje Znanje osnovnih modelskih postopkov, razumevanje učinkov posameznih modelskih orodij.	**Knowledge and understanding:** Knowledge of basic model-based procedures, understanding the impact of various model-based tools.

Uporaba Obvladovanje modeliranja podatkov in postopkov stohastične analize. **Refleksija** Razumevanje odnosa med pojavov in njegovim modelom, refleksija kompleksnosti. **Prenosljive spretnosti - niso vezane le na en predmet** Predstavitve podatkov in rezultatov obdelave – zahtevnejše oblike grafičnih prikazov. Obvladovanje računalniških algoritmov z veliko časovno in prostorsko zahtevnostjo.	**Application:** Mastering data modeling and methods of stochastic analysis. **Reflection:** Understanding the relationship between phenomena and its model. **Transferable skills:** Presentation of data and results of data processing, advanced forms of graphic presentations. Mastering computing algorithms with a large temporal and spatial complexity.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, diskusija tedenskih projektov, konzultacije.	Lectures, discusssion of weekly projects.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Skupna ocena tedenskih projektov, ocena zaključnega projekta; ocene 1-5 (negativno), 6-10 (pozitivno;) ob upoštevanju Statuta UL in fakultetnih pravil.	**100%**	Final score from the weekly pojects. Marks: 1-5 (not passed), 6-10 (passed) (according to the UL rules).

Reference nosilca / Lecturer's references:

- KODRE, Alojz, PADEŽNIK GOMILŠEK, Jana, ARČON, Iztok, AQUILANTI, Giuliana. X-ray atomic absorption of cesium and xenon in L-edge region. *Phys. rev., A*, 2010, vol. 82, issue 2, str. 022513-1-022513-7.
- ČOPAR, Simon, KODRE, Alojz. One-dimensional simulation of thin-film-edge retraction.

Phys. rev., E Stat. nonlinear soft matter phys. (Print), 2010, vol. 82, str. 056307-1-056307-5

- KODRE, Alojz, TELLIER, Jenny, ARČON, Iztok, MALIČ, Barbara, KOSEC, Marija. Extended x-ray absorption fine structure study of phase transitions in the piezoelectric perovskite K[sub](0.5)Na[sub](0.5)NbO[sub]3. *J. appl. phys.*, 2009, vol. 105, no. 11, str. 113528-1-113528-4.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Optične metode v medicini
Course title:	Optical methods in medicine

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Magistrski študijski program 2. stopnje Medicinska fizika	Medicinska fizika	**1 ali 2**	**Prvi ali drugi**
Second cycle academic study program Medical physics	Medical physics	**1 or 2**	**First or second**

Vrsta predmeta / Course type	izbirni predmet/elective course
Univerzitetna koda predmeta / University course code:	???

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike študija	Samost. delo Individ. work	ECTS
30		**15**			**105**	**6**

Nosilec predmeta / Lecturer:	izr. prof. dr. Boris Majaron

Jeziki / Languages:	**Predavanja / Lectures:**	**Slovensko/Slovene**
	Vaje / Tutorial:	**Slovensko/Slovene**

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Vpis v letnik	Regular enrolement

Vsebina:	**Content (Syllabus outline):**
Optika bioloških tkiv: absorpcija (glavni kromofori, optično okno), elastično sipanje (sipalni presek, fazna funkcija, Rayleigh-jev in Mie-jev režim), večkratno sipanje (transportna teorija, difuzijska aproksimacija, Monte Carlo), meritve optičnih lastnosti Diagnostične tehnike: pretočna citometrija, difuzna refleksija, fluorescenca (nativna, eksogena), Ramanska spektroskopija. Tehnike globinskega slikanja: optična koherenčna tomografija, difuzijska optična	Optics of biological tissues: absorption (main chromophors, optical window), elastic scattering (scattering cross section, phase function, Rayleigh and Mie regime), multiple scattering regime (transport theory, diffusion approximation, Monte Carlo), measurement of optical properties. Diagnostic techniques: flow cytometry, diffuse reflectance, fluorescence (native, exogenous), Raman spectroscopy. Tomographic imaging techniques: optical

tomografija, optoakustična tomografija, fototermalna radiometrija. Linearni odziv tkiva na obsevanje: dinamika toplotnega transporta (časovne konstante, perfuzija), termoelastične napetosti. Fotokoagulacija: kinetika denaturacije proteinov (laserska intersticialna termoterapija), lasersko varjenje in spajkanje, selektivna fototermoliza (terapija žilnih obolenj, senčenje). Fototermalna laserska ablacija: metrika in hevristični modeli, mikroskopski procesi (fazna eksplozija, vretje v votlini), senčenje v izmetu, primeri kliničnih aplikacij (površinska ablacija v dermatologiji, laserski skalpel, obdelava trdih tkiv) Fotomehanska ablacija: tvorba plazme in udarnih valov, kavitacija, klinični primeri (litotripsija, okulistika) Fotoionizacija (laserski keratom). Fotokemični pojavi: fotokemična ablacija (fotorefraktivna keratektomija), foto-dinamična terapija (onkologija). Nevarnosti in zaščita pred laserskim sevanjem	coherence tomography, diffused optical tomography, optoacoustic tomography, photothermal radiometry. Linear response of tissue to irradiation: dynamics of heat transport (time constants, perfusion), thermoelastic stress. Photocoagulation: kinetics of protein denaturisation (laser interstitial thermotherapy, laser welding and soldering), selective photothermolysis (therapy of vascular malformations, optical screening). Photothermal laser ablation: metrics and heuristic models, microscopic processes (phase explosion, confined boiling), screening by ablation debris, clinical examples (superficial ablation in dermatology, laser scalpel, treatment of hard tissues). Photomechanical effects: formation of plasma and shock waves, cavitation, clinical examples (lithotripsy, eye surgery). Photoionisation (laser keratom). Photochemical effects: photochemical decomposition (photorefractive ceratectomy), photodynamic therapy (oncology). Laser hazards and safety measures.

Temeljni literatura in viri / Readings:

- Ashley J. Welch, Martin J.C. van Gemert, eds., *Optical-Thermal Response of Laser-Irradiated Tissue*, 2nd ed., Springer (Dordrecht, 2011), 958 p. ISBN: 978-90-481-8830-7
- Markof H. Niemz, *Laser-Tissue Interactions; Fundamentals and Applications*, 3rd ed., Springer-Verlag (Berlin, 2007), 297 p. ISBN: 978-3-540-72191-8
- L.V. Wang, H-I. Wu, Biomedical Optics; Principles and Imaging, Wiley-Interscience (Hoboken, NJ, 2007), 362 p., ISBN: 978-0-471-74304-0

Cilji in kompetence:	**Objectives and competences:**
Študenti pridobijo osnovno razumevanje pomembnejših optičnih metod za medicinsko diagnostiko, terapijo, mikroskopijo in tomografijo. Predmetno specifične kompetence: Poznavanje in osnovno razumevanje procesov pri interakciji UV, vidne in IR svetlobe z biološkimi tkivi. Poznavanje in razumevanje značilnih procesov pri obsevanju z močno	Students gain fundamental knowledge of the most important optical methods for medical diagnostics, therapy, microscopy and tomography. Competences: Knowledge and basic understanding of processes of light interaction with tissue in UV and IR range. Knowledge and understanding of typical processes during strong laser irradiation

lasersko svetlobo in pomembnejših primerov terapevtskih aplikacij. Seznanitev z naprednimi optičnimi metodami v medicinski diagnostiki, tomografiji in mikroskopiji bioloških vzorcev. Razumevanje specifičnih nevarnosti laserskih izvorov in zaščite pred njimi.	and important therapeutic applications. Familiarity of advanced optical methods in medical diagnostics, tomography and microscopy of biological samples. Understanding of specific hazards of laser source and necessary protection.
Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: Študent dobi pregled nad pojavi pri obsevanju bioloških tkiv z neionizirajočo svetlobo in spozna osnovne odvisnosti od parametrov obsevanja. Spozna in pridobi osnovno razumevanje pomembnejših optičnih metod za medicinsko diagnostiko in terapijo, ter naprednejših tehnik mikroskopije in tomografije. Razume nevarnosti laserskih izvorov in načine za zaščito uporabnikov. **Uporaba:** Uporaba in kombiniranje osnovnih fizikalnih znanj na obravnavanih primerih medicinske diagnostike, terapije in mikroskopije. **Refleksija:** Kritično ovrednotenje matematično- fizikalnih modelov pri uporabi na kompleksnih bioloških sistemih. Kritična refleksija prednosti in slabosti posameznih optičnih metod v klinični praksi. **Prenosljive spretnosti - niso vezane le na en predmet:** Kritično soočanje znanj iz posameznih fizikalnih disciplin v obravnavanih bioloških sistemih in elektrooptičnih napravah. Sposobnost kritične analize mestoma nasprotujočih si trditev v literaturi z mlajših raziskovalnih področij. Seznanjanje s problemi in omejitvami pri medicinskih raziskavah in aplikacijah (npr. etični in statistični vidiki).	**Knowledge and understanding:** Obtaining knowledge about non-ionizing radiation effects on biological tissues and fundamental dependence on irradiation parameters. Obtains basic understanding of fundamental optical methods for medical diagnostics and therapy, as well as advanced microscopic and tomographic techniques. Understand laser source hazards and methods of protection. **Application:** Use and application of the fundamental physics concepts on the considered applications of medical diagnostics, therapy and microscopy. **Reflection:** Critical assessment of the use of mathematical and physical models on complex biological systems. Critical evaluation of advantages and disadvantages of various optical methods in clinical practice. **Transferable skills:** Critical synthesis of knowledge of various physics disciplines in biological systems using electrooptical systems. Ability to critically analyze apparently conflicting results in the modern literature. Understanding the problems and limitations of medical applications (e.g., ethical and statistical concepts)
Metode poučevanja in učenja:	**Learning and teaching methods:**

Predavanja, računske vaje, konzultacije.	Lectures, computational exercises, consultations.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Ustni izpit Ocene: 1-5 (negativno), 6-10 (pozitivno) (po Statutu UL).	**100%**	Oral exam Marks: 1-5 (not passed), 6-10 (passed) (according to the UL rules).

Reference nosilca / Lecturer's references:

izr. prof. dr. Boris Majaron

- M. Milanič, B. Majaron. Energy deposition profile in human skin upon irradiation with a 1,342 nm Nd:YAP laser. *Lasers Surg. Med.*, vol. 45, 8-14, 2013.
- B. Majaron, J.S. Nelson. Laser Treatment of Port Wine Stains. in: *Optical-Thermal Response of Laser-Irradiated Tissue*, A.J. Welch and M.J.C. van Gemert eds., 2nd ed., Springer, 859–914, 2011.
- M. Milanič, W. Jia, J. S. Nelson, B. Majaron, Numerical optimization of sequential cryogen spray cooling and laser irradiation for improved therapy of port wine stain, *Laser Surg. Med.* 43: 164-175, 2011.
- M. Milanič, I. Serša, B. Majaron, A spectrally composite reconstruction approach for improved resolution of pulsed photothermal temperature profiling in water-based tissues, *Phys. Med. Biol*. 54, 2829–2844, 2009.
- U. Ahčan, P. Zorman, D. Recek, S. Ralca, B. Majaron, Port wine stain treatment with a dual-wavelength Nd:YAG laser and cryogen spray cooling: a pilot study*, Lasers Surg. Med.* 44, 164-167, 2004.
- B. Majaron, L.O. Svaasand, G. Aguilar, J.S. Nelson, Intermittent cryogen spray cooling for optimal heat extraction during dermatologic laser treatment, *Phys. Med. Biol.* 47, 3275-3289, 2002.
- B. Majaron, S. M. Srinivas, H.-en L. Huang, J. S. Nelson, Deep coagulation of dermal collagen with repetitive Er:YAG laser irradiation, *Lasers Surg. Med.* 26, 215-222, 2000.
- B. Majaron, P. Plestenjak, M. Lukač, Thermo-mechanical laser ablation of soft biological tissue: modeling the micro explosions, *Appl. Phys.* B 69, 71-80, 1999.
- B. Majaron, D. Šušterčič, M. Lukač, U. Skalerič, N. Funduk, Heat diffusion and debris screening in Er:YAG laser ablation of hard biological tissues, *Appl. Phys.* B 66, 479-487, 1998.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Radiobiologija
Course title:	Radiobiology

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Univerzitetni študijski program 2. stopnje Medicinska fizika	Medicinska fizika	**1 ali 2**	**Prvi ali drugi**
Second cycle academic study program Medical physics	Medical physics	**1 or 2**	**First or second**

Vrsta predmeta / Course type	izbirni predmet/elective course
Univerzitetna koda predmeta / University course code:	???

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **work**	**Druge oblike študija**	**Samost. delo** **Individ. work**	**ECTS**
45	**15**				**60**	**6**

Nosilec predmeta / Lecturer:	prof. dr. Gregor Serša, doc. dr. Maja Čemažar

Jeziki / Languages:	**Predavanja / Lectures:**	**Slovensko/Slovene**
	Vaje / Tutorial:	**Slovensko/Slovene**

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Vpis v letnik	Regular enrolement

Vsebina:	**Content (Syllabus outline):**
Proliferacija celic in značilnosti rasti tumorjev: kinetika rasti celic in tumorjev, dejavniki, ki vplivajo na rast tumorjev, testi za merjenje kinetike rasti tumorjev. Celična proliferacija in organizacija normalnih tkiv: organizacija normalnih tkiv glede na proliferacijo celic in z njo povezan odgovor na sevanje. Učinki sevanja na celico: koncept reprodukcijske smrti celice, klonogenosti celic, krivulje preživetja celic, modeli preživetnih	Cell proliferation and tumor growth characteristics: kinetics of cellular and tumor growth, factors that affect tumor growth, test of tumor growth. Cell proliferation and organization of normal tissues: organization of normal tissues depending on cell proliferation and with it connect radiation response Radiation effects on cells: reproductive cell death concepts, cell clonogenity, cell survival curves, models of cell survival curves, DNA

krivulj, poškodba DNA in drugih celičnih organelov, genetska kontrola odgovora celic na sevanje. Odgovor in toleranca normalnih tkiv na sevanje:pristopi za vrednotenje poškodb, testi za oceno funkcionalnosti in preživetja klonogenih celic, zgodnje in kasne posledice sevanja. Radiobiologija tumorjev: pristopi za vrednotenje protitumorskega delovanja in vivo Radiosensitivnost celic: odvisnost od celičnega ciklusa, proliferacijske sposobnosti, diferenciranosti celic in popravila radiacijske poškodbe Hitrost doze in čas obsevanja pri frakcionirani radioterapiji: hiperfrakcionacija in pospešena frakcionacija. Biološke osnove kombiniranega zdravljenja: koncept kombiniranega zdravljenja, radiosenzibilizatorji in radioprotektorji, učinek kisika, modifikatorji oksigenacije tumorjev, kemoterapija, imunska terapija, genska terapija.	damage and damage of other organels, genetic control of the cellular response to radiation Response and normal tissue tolerance: normal tissue radiation damage assessment approaches, functional tests and clonogen survival tests, early and late tissue toxicity Tumor radiobiology: approaches to evaluate anti-tumor effects in vivo Radiosensitivity of cells: dependence on cell cycle, proliferative potential, cell differentiality and radiation damage repair

Temeljni literatura in viri / Readings:

- E.J.Hall: *Radiobiology for the Radiologist*, Lippincott Williams and Wikins Publishers; 5th edition, 588 pp.. ISBN: 0781726492
- I.F. Tannock in R.P. Hill: *The Basic Science of Oncology*, McGraw Hill, 3rd edition, 539 pp. ISBN 0071054847
- G.G. Steel: *Basic Clinical Radiobiology*, Edward Arnold, 3rd edition, 280 pp. ISBN: 0340807830

Cilji in kompetence:	**Objectives and competences:**
Spoznati študente z osnovami radiobiologije in najnovejšimi spoznanji na področju radiobiologije, ki vodijo v bolj učinkovito delovanje radioterapije Predmetno specifične kompetence: Poznavanje in razumevanje specifičnih bioloških lastnosti tumorskih celic in tumorjev. Poznavanje učinkov ionizirajočega sevanja na različne biološke sisteme, od molekularnega nivoja do organizma. Poznavanje in razumevanje bioloških principov kombiniranih terapij – radiosenzibilizacija in radioprotekcija.	Students get familiar with the theoretical basis of radiobiology that lead to more effective radiation therapy. Competences: Understanding of the specific biological properties of tumor cells and tumors. Understanding of the radiation effects on different biological systems, from the molecular to organ level. Understanding of the basic biological principles of the combined therapies – radiosensitivity and radioprotection.

Predvideni študijski rezultati:	Intended learning outcomes:
Znanje in razumevanje: Pridobitev znanja iz področja bazične in klinične radiobiologije. **Uporaba:** Uporaba znanj s področja radiobiologije za spoznavanje in reševanje problemov v radioterapiji. **Refleksija:** Kritično ovrednotenje pridobljenega teoretičnega znanja o bazični in klinični radiobiologiji s praktičnim delom v radioterapiji in diagnostični radiologiji **Prenosljive spretnosti - niso vezane le na en predmet:** Sposobnost razumevanja bioloških in temeljnih medicinskih strok s področja ionizirajočega sevanja in komunikacije s strokovnjaki s teh področij.	**Knowledge and understanding:** Understanding fundamental concepts of basic and clinical radiobiology. **Application:** Use of the radiobiology knowlege for recognision and solving of the problems in radiation therapy. **Reflection:** Critical evaluation of the fundamental knowledge of basic and clinical radiobiology in radiotherapy and diagnostic radiology. **Transferable skills:** Ability to understand biomedical fields related to ionizing radiation and ability to effectively communicate with the experts from these fields.

Metode poučevanja in učenja:	Learning and teaching methods:
Predavanja, seminarji, konzultacije.	Lectures, seminars, consultations.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	Assessment:
Izpit, seminarska naloga Ocene: 1-5 (negativno), 6-10 (pozitivno) (po Statutu UL).	**50%** **50%**	Oral exam, seminar Marks: 1-5 (not passed), 6-10 (passed) (according to the UL rules).

Reference nosilca / Lecturer's references:

prof. dr. Gregor Serša, doc. dr. Maja Čemažar

- Čemažar M, Grošel A, Glavač D, Kotnik V, Skoberne M, Kranjc S, Mir LM, Andre F, Opolon P, Serša G. *Effects of electrogenetherapy with p53wt combined with cisplatin on survival of human tumor cell lines with different p53 status.* DNA Cell Biol 2003; **22:** 765-75.
- Čemažar M, Wilsom I, Dachs GU, Tozer G, Serša G. *Direct visualization of electroporation-assisted in vivo gene delivery to tumors using intravital microscopy – spatial and time dependent distribution.* BMC Cancer 2004; 4:81. doi:10.1186/1471-2407-4-81
- Snoj M, Rudolf Z, Čemažar M, Jančar B, Serša G. *Successful sphincter-saving treatment of anorectal malignant melanoma with electrochemotherapy, local excision and adjuvant brachytherapy.* Anti-Cancer Drugs 2005; **16:** 345-8.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Seminar
Course title:	Seminar

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Magistrski študijski program 2. stopnje Medicinska fizika	Medicinska fizika	**1 ali 2**	**Prvi ali drugi**
Second cycle academic study program Medical physics	Medical physics	**1 or 2**	**First or second**

Vrsta predmeta / Course type	izbirni predmet/elective course
Univerzitetna koda predmeta / University course code:	

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Klinične vaje** **work**	**Druge oblike študija**	**Samost. delo** **Individ. work**	**ECTS**
	60				**120**	**6**

Nosilec predmeta / Lecturer:	prof. dr. Peter Križan

Jeziki / Languages:	**Predavanja / Lectures:**	**Slovensko/Slovene**
	Vaje / Tutorial:	**Slovensko/Slovene**

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Vpis v letnik	Regular enrolement

Vsebina:	**Content (Syllabus outline):**
Program seminarjev se oblikuje vsako leto, pretežno zajema snov iz vseh področij fizike, ki se raziskovalno gojijo na FMF in v sorodnih raziskovalnih institucijah. Kot mentorji pri seminarjih nastopajo učitelji UL in raziskovalci na sorodnih raziskovalnih institucijah.	The program is determined each year, and typically covers topics in physics research which are pursued at the faculty as well as in the related institutions. Supervisors of students are lecturers at UL as well as researchers at related institutions.

Temeljni literatura in viri / Readings:

- William Strunk, Jr., E. B. White, "The Elements of Style".

Cilji in kompetence:	**Objectives and competences:**
Študenti se pri predmetu po eni strani naučijo predstaviti širši fizikalni publiki znanstvene teme, s katerimi se sami ukvarjajo, po drugi strani pa se navadijo na znanstvene diskusije, ki take predstavitve spremljajo.	Students gain exerience in presenting to a broad physics audience; they also gain experience in scientific discussions.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: Poznavanje novosti na širšem področju fizike, poznavanje osnovnih pravil dobrega pisanja člankov in priprave predavanj. **Uporaba:** Predstavitev lastnega dela, pisanje člankov, priprava predavanja, sodelovanje v diskusiji. Prenos spoznanj iz enega področja fizike na drugo. **Refleksija:** Kritično presojanje podatkov v literaturi, kritično presojanje predavanj drugih predavateljev. **Prenosljive spretnosti - niso vezane le na en predmet:** Predstavitev lastnega dela, pisanje člankov, priprava predavanja, sodelovanje v diskusiji.	**Knowledge and understanding:** Obtaining a broad knowledge in recent developements in physics. Knowledge of basic principles of writing scietific papers and preparing of lectures. **Application:** Presentation of research work, writing of scientific papers. Taking part in scientific discussions. Transfer of knowledge and experience between variuos areas in physics. **Reflection:** Critical assessment of the data found in the literature. Critical evaluation of lecturers. **Transferable skills:** Presentation of research work, writing of scientific papers. Taking part in a discussion.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja.	Lectures.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Obisk predavanj	**100%**	Attending the lectures.

Reference nosilca / Lecturer's references:

prof. dr. Peter Križan

- I. Adachi et al. [Belle Collaboration], Measurement of B- → tau- nu with a Hadronic Tagging Method Using the Full Data Sample of Belle, Phys. Rev. Lett. 110 (2013) 131801
- I. Adachi et al., Precise measurement of the CP violation parameter sin2phi_1 in B0→ c c K0

decays, Phys. Rev. Lett. 108 (2012) 171802

- P. Križan, Overview of particle identification techniques, Nucl. Instrum. Meth. A706 (2013) 48.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Statistične metode v medicini
Course title:	Statistical methods in medicine

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Magistrski študijski program 2. stopnje Medicinska fizika	Medicinska fizika	**1 ali 2**	**Prvi ali drugi**
Second cycle academic study program Medical physics	Medical physics	**1 or 2**	**First or second**

Vrsta predmeta / Course type	izbirni predmet/elective course
Univerzitetna koda predmeta / University course code:	

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike študija	Samost. delo Individ. work	ECTS
30		**15**			**105**	**6**

Nosilec predmeta / Lecturer:	doc. dr. Tomaž Podobnik

Jeziki / Languages:	**Predavanja / Lectures:**	**Slovensko/Slovene**
	Vaje / Tutorial:	**Slovensko/Slovene**

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Vpis v letnik	Regular enrolement

Vsebina:	**Content (Syllabus outline):**
Verjetnost: definicija verjetnosti, pravili za množenje in seštevanje, Bayesov teorem. Vzorčenje: osnove vzorčenja, hipergeometrična in binomska porazdelitev. Teorija verjetnostnih porazdelitev: naključne spremenljivke, diskretne in zvezne porazdelitve, porazdelitvena funkcija, porazdelitvena gostota, karakteristična funkcija in njene izpeljanke, primeri verjetnostnih porazdelitev, centralni limitni izrek.	Probability: definition of probability, rules of multiplication and addition, Bayesian theorem. Sampling: Principles of sampling, hypergeometric and binomial distribution. Theory of probability distributions: random variables, discrete and continuous distributions, the distribution function, the density distribution, characteristic function and its derivatives, examples of probability distributions, the central limit theorem. Monte Carlo (MC) generators of (pseudo)

Metoda Monte Carlo (MC): generatorji (psevdo)naključnih števil, metoda zgreši-zadeni, integriranje, generiranje različnih porazdelitev, MC metoda markovskih verig. Ocenjevanje parametrov: Bayesov teorem, točkovne in intervalske ocene, konsistentnost metode, metoda največje zanesljivosti, zadostnost. Verjetnost a priori: pripisovanje apriornih verjetnostnih porazdelitev, robustnost. Preizkušanje hipotez: testiranje binarnih hipotez, hkratno testiranje več hipotez (izbira modela).	random numbers, the hit-miss method, integration, generation of various distributions, MC method in Markov chains. Parameter estimation: Bayes theorem, point estimates and interval estimates, consistency of the method, the maximum likelihood method, sufficiency. The a priori probability: the attribution of a priory probability distributions, robustness. Hypothesis testing: testing of binary hypotheses, simultaneous test of multiple hypotheses (model selection).

Temeljni literatura in viri / Readings:

- D.S.Sivia: Data Analysys – A Bayesian Tutorial, Oxford University Press, 1996
- E.T.Jaynes: Probability Theory – The Logic of Science, Cambridge University Press, 2003.
- H.Frank, S.C.Althoen: Statistics – Concepts and Applications, Cambridge University Press, 1994.

Cilji in kompetence:	**Objectives and competences:**
Cilji: Seznaniti študente z osnovnimi metodami uporabe verjetnostnega računa za analizo podatkov v medicinski fiziki. Predmetno specifične kompetence: Razumevanje zakonov verjetnosti in znanstvenega sklepanja. Sposobnost uporabe verjetnostnega računa za analizo podatkov v medicinski fiziki. Sposobnost kritičnega ovrednotenja teoretičnih napovedi na podlagi meritev na končno velikem vzorcu.	Objectives: Students will learn basic knowledge on probability theory based methods for the analysis data in medical physics applications. Competences: Understanding of basic laws of probability and of scienfitic reasoning. Ability to apply probability methods to the analysis of data in medical physics. Ability to critically compare theoretical predictions and measurements on a finite data sample.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: Pridobitev osnovnega znanja o znanstvenem sklepanju in o metodah uporabe verjetnostnega računa za analizo podatkov v medicinski fiziki.	**Knowledge and understanding:** Obtaining basic knowledge on probability theory based methods for the analysis data in medical physics applications. **Application:**

Uporaba: Uporaba statistike pri reševanje problemov v načrtovanju, izvedbi in ovrednotenju medicinskega slikanja in pri obdelavi izbranih podatkov. **Refleksija:** Kritično ovrednotenje teoretičnih napovedi na podlagi meritev na končnem velikem vzorcu. **Prenosljive spretnosti - niso vezane le na en predmet:** Sposobnost zbiranja podatkov ter razlaganja in vrednotenja rezultatov.	Use of basic probability concepts for solving problems in the analysis of data in medical physics. **Reflection:** Critical evaluation of theoretical predictions in comparison to measurements on a finite data sample. **Transferable skills:** Ability to collect data and explain obtained results.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Sprotne domače naloge, zaključna naloga.	Regular homework - problem solving, final project.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Ocene sprotnih domačih nalog, ocena končnega projekta. Ocene: 1-5 (negativno), 6-10 (pozitivno) (po Statutu UL).	**50% (domače naloge/home work)** **50% (zaključna naloga/final project)**	Regular homeworks (problem solving), final project. Marks: 1-5 (not passed), 6-10 (passed) (according to the UL rules).

Reference nosilca / Lecturer's references:

Doc. dr. Tomaž Podobnik

- T. Podobnik and T. Živko, On probabilistic parametric inference, Journal of Statistical Planning and Inference 142 (2012) 3152–3166
- B. Kerševan, B. Golob, G. Kernel, T. Podobnik, Nucl. Instr. Meth. A462 (2001) 536
- DELPHI Collaboration, ABDALLAH, J., BRAČKO, Marko, GOLOB, Boštjan, KERNEL, Gabrijel, KERŠEVAN, Borut Paul, PODOBNIK, Tomaž, ZAVRTANIK, Danilo, et al. Measurements of CP-conserving trilinear gauge boson couplings WWV (V [equivalent] [gamma], Z) in e[sup]+ e[sup]- collisions at LEP2. The European physical journal. C, ISSN 1434-6044, Mar. 2010, vol. 66, issue 1/2, str. 35-56.
- DELPHI Collaboration, ABDALLAH, J., BRAČKO, Marko, GOLOB, Boštjan, KERNEL, Gabrijel, KERŠEVAN, Borut Paul, PODOBNIK, Tomaž, ZAVRTANIK, Danilo, et al. Search for single top quark production via contact interactions at LEP2. The European physical journal. C, ISSN 1434-6044, 2011, vol. 71, no. 2, str. 1555-1-1555-13.

UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Zdravstvena fizika
Course title:	Health physics

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Magistrski študijski program 2. stopnje Medicinska fizika	Medicinska fizika	**1 ali 2**	**Prvi ali drugi**
Second cycle academic study program Medical physics	Medical physics	**1 or 2**	**First or second**

Vrsta predmeta / Course type obvezni predmet/core course

Univerzitetna koda predmeta / University course code: ???

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike študija	Samost. delo Individ. work	ECTS
45	**15**	**15**			**60**	**6**

Nosilec predmeta / Lecturer: prof. dr. Andrej Likar

Jeziki / Languages:	
Predavanja / Lectures:	**Slovensko/Slovene**
Vaje / Tutorial:	**Slovensko/Slovene**

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	Prerequisits:
Vpis v letnik	Regular enrolement

Vsebina:	Content (Syllabus outline):
Viri ionizirajočih sevanj, naravni izotopi, kozmično sevanje, gorivni ciklus jedrskih elektrarn, pospeševalniki, nevtronski generatorji, viri rentgenskh žarkov, jedrske eksplozije, radiološke in jedrske nesreče. Radioaktivne pretvorbe, procesi, razpadne sheme, hitrosti razpadov, radioaktivni nizi, ravnovesje, aktivacija, fisija in njeni produkti, kritikalnost, Interakcija sevanja s snovjo. Merjenje radioaktivnosti. Splošni principi,	Ionizing radiation sources, natural isotopes, cosmic radiation, fuel cycles of nuclear power plants, accelerators, neutron generators, X-ray sources, nuclear explosions, radiological and nuclear accidents Radioactive transformations, processes, decay schemes, radiation rates, radioactive decay schemes, equilibrium, activation, fission and products, criticality Interaction of radiation with matter Measurement of radioactivity. Basic principles,

instrumentacija, merske tehnike Dozimetrija. Osnove, izračuni doze, merjenje doz Izračun radiacijskih ščitov, ščiti za delce alfa, beta in fotone, nevtrone, protone in lahke ione Biološki učinki sevanja. Učinki na celičnem nivoju, deterministični, stohastični učinki, osnove varstva pred ionizirajočim sevanjem, legislacija. Radiološki nadzor okolja. Zunanje sevanje, nadzor zraka, vode, tal in prehrambene verige Tehnike nadzora okolja. Meritve hitrosti doze, visokoločljivostna spektroskopija gama, spektrometrija alfa, radiokemijske metode Modeliranje širjenja radioaktivnega onesnaženja Programi nadzora, Splošno, v Sloveniji.	instrumentation, measurement techniques Dosimetry. Basics, dose calculation, dose measurements Shielding calculations, alpha, beta and gamma particles shields, neutron, proton and heavy ion shields. Biological effects of radiation. Effects on the cellular level, deterministic and stochastic effects, basics of radiation protection, regulatory issues. Radiological monitoring. Air, water, soil and food monitoring. Techniques of radiological monitoring. Measurements of radiation dose rates, high-resolution gamma spectroscopy, alpha spectroscopy, radiochemical methods. Modeling of the radiation dispersion Monitoring programs. In general. Specific to Slovenia.

Temeljni literatura in viri / Readings:

- H. Cember, Introduction to Health Physics, 3rd ed., McGraw-Hill, 1996
- J. E. Martin, Physics for Radiation Protection, John Wiley & Sons, Inc., New York, 2000
- Annals of ICRP, 1990 Recommendations of the International Commission on Radiological Protection, ICRP Publication 60
- International Basic Safety Standards for Protection Against Ionizing Radiation and for Safety of Radiation Sources, IAEA, Safety Series No. 115
- Slovenska zakonodaja

Cilji in kompetence:	**Objectives and competences:**
Študent se seznani z bistvenimi fizikalnimi principi in bazičnimi podatki, ki jih potrebuje pri ovrednotenju sevalne nevarnosti in pri načrtovanju zaščite pred sevanjem. Koncepti so ilustrirani s številnimi praktičnimi nalogami. Predmet predstavlja odskočno desko pri nadaljnjem študiju dozimetrije, merjenj ionizirajočega sevanja in drugih sorodnih a bolj specializiranih področij.	Students get familiar with the health physics principles and basic data that is needed in evaluation of radiation hazard and planning of radiation shielding. Concepts are illustrated with practical examples. This course links with other courses on dosimetry, radiation measurement and other more specific fields.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanje in razumevanje: Predmet vpeljuje v osnove zdravstvene fizike, merjenja ionizirajočega sevanja in varstva pred njim ter seznanja z načini radiološkega nadzora okolja.	**Knowledge and understanding:** Obtaining fundamental knowledge of health physics, ionization measurement measurements and radiation safety.

Uporaba: Uporaba znanj pri radiološkem nadzoru delovnega okolja. **Refleksija:** Opredelitev stopnje nevarnosti v različnih radioloških situacijah in načrtovanje ukrepov. **Prenosljive spretnosti - niso vezane le na en predmet:** Sposobnost ovrednotenja izmerkov ter na osnovi zaključkov znati klasificirati stopnjo radiološke nevarnosti in predlagati ustrezne ukrepe.	**Application:** Use in radiological monitoring of environment. **Reflection:** Assessment of danger level in various radiological incidences and planning of mitigation procedures. **Transferable skills:** Ability to collect the data and critically evaluate the level of radiation hazard and recommend adequate mitigation procedures.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, vaje, domače naloge, konzultacije.	Lectures, problem solving, homework, consultations.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Izpit iz teorije, izpit iz vaj, domača naloga Ocene: 1-5 (negativno), 6-10 (pozitivno) (po Statutu UL). Predmet je tudi del komisijskega izpita ob koncu študija. Ocene: opravil, ni opravil (po Statutu UL).	**50% (izpit/exam)** **50% (vaje/probl)**	Written exam (theory), written exam (problem solving), homework Marks: 1-5 (not passed), 6-10 (passed) (according to the UL rules). Subject is also a part of the final committee exam. Marks: pass/fail (according to the UL rules).

Reference nosilca / Lecturer's references:

prof. dr. Andrej Likar

- VIDMAR, Tim, LIKAR, Andrej, KORUN, Matjaž, VODENIK, Branko, KOSSERT, K. A novel approach to the analysis of HPGe spectra. Part 1. *Nucl. instrum, methods phys res., Sect. A, Accel.*. [Print ed.], 2008, vol. 587, no. 1, str. 68-75.
- LIKAR, Andrej, LIPOGLAVŠEK, Matej, VENCELJ, Matjaž, VIDMAR, Tim, BARK, R. A., GUEORGUIEVA, E., KOMATI, F. S., LAWRIE, J. J., MALIAGE, S. M., MULLINS, S. M., MURRAY, S. H. T., RAMASHIDZHA, T. Proton capture to continuum states of [sup](209)Bi. *Phys. rev. C. Nucl. phys.*, 2006, vol. 73, str.044609-1-044609-8.
- Vidmar T., Likar A. *Calculation of total efficiencies of extented samples for HPGe detectors.* Nucl. instrum, methods phys res., Sect. A, Accel., 2005, vol. 555, str. 251-254.