

LASERSKI SISTEMI

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Laserski sistemi
Course title:	Laser Systems
Članica nosilka/UL Member:	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semestri	Izbirnost
Strojništvo - Razvojno raziskovalni program, druga stopnja, magistrski	Mehatronika in laserska tehnika (smer)	1. letnik	2. semester	obvezni

Univerzitetna koda predmeta/University course code:	0566815
Koda učne enote na članici/UL Member course code:	6058-M

Predavanja /Lectures	Seminar /Seminar	Vaje /Tutorials	Klinične vaje /Clinical tutorials	Druge oblike študija /Other forms of study	Samostojno delo /Individual student work	ECTS
30		30			65	5

Nosilec predmeta/Lecturer:	prof. dr. Matija Jezeršek
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Izvajalci predavanj:	
Izvajalci seminarjev:	
Izvajalci vaj:	
Izvajalci kliničnih vaj:	
Izvajalci drugih oblik:	
Izvajalci praktičnega usposabljanja:	

Vrsta predmeta/Course type:	Obvezni strokovni predmet na smeri Mehatronika in laserska tehnika, ki je izbirni strokovni predmet na ostalih smereh./Compulsory specialised course in the study of Mechatronics and laser technology, which is an elective specialised course in other fields of study.
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Jeziki/Languages:	Predavanja/Lectures:	Slovenščina
	Vaje/Tutorial:	Slovenščina

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

Izpolnjevanje pogojev za vpis v Magistrski študijski program II. stopnje Strojništvo - Razvojno raziskovalni program.

Prerequisites:

Meeting the enrollment conditions for the Master's study programme of Mechanical Engineering - Research and Development program.

Vsebina:

- Uvod
- Pregled vsebine, ciljev in kompetenc

Content (Syllabus outline):

- Introduction
- Review of the content, goals and competencies

- Predstavitev dela na laboratorijskih vajah - Predstavitev ocenjevanja 2. Gradniki laserskih sistemov - Laser, optika za vodenje in fokusiranje, - 3D aktuatorji in roboti, - krmilniki in diagnostični sistemi. 3. Pregled laserjev in njihove značilnosti - Klasifikacija, - pomembni parametri za obdelovalne in merilne aplikacije, - tipične vrednosti in medsebojna primerjava. 4. Proces razvoja laserskih sistemov - Konceptualizacija, - zahteve in omejitve, - zasnova, - modeliranje in analiza optičnih lastnosti, - detajliranje, - prototip in evalvacija. 5. Vplivi okolice - Nečistoče, - temperatura, - vibracije, - vlaga, - laserske poškodbe optičnih površin. 6. Optomehanske karakteristike materialov - Spektralna transmisivnost, reflektivnost in absorptivnost posameznih vrst materialov, lomni količnik, disperzija, termični raztezki, trdota itn. - Primeri prozornih materialov (lastnosti, obdelovalne karakteristike), materialov za zrcala, za mehanske komponente, lepila, tesnila. 7. Optične aberacije - Fizikalna razlaga, - matematični popis, - ukrepi za zmanjševanje aberacij. 8. Računalniško načrtovanje optičnih sistemov 1 - Matematični popis sledenja žarkov, - paraksialni približek in paraksialne lastnosti optičnega sistema 9. Računalniško načrtovanje optičnih sistemov 2 - Numerično vrednotenje aberacij z metodo sledenja žarkov, - tehnike prikaza aberacij, - optimizacija optičnih sistemov. 10. Pritrjevanje optičnih elementov - Analiza odstopanj optičnih elementov od idealne pozicije, tehnike centriranja sferičnih leč, tehnike pozicioniranja prizmatičnih elementov - Hlajenje optike in termični raztezki - Primeri 11. Uravnavanje in kontrola optičnih sistemov - Optični pozicionirni sistemi, - zagotavljanje soosnosti/vzporednosti med geometrijsko osjo in laserskim snopom. 12. Sistemi za vodenje laserskega snopa - Leteča optika, artikulirana roka, skenirna glava (1D, 2D in 3D), integracija z robotsko roko - Zasnova in matematični preračuni	- Presentation of lab work - Presentation of assessment 2. The building blocks of laser systems - Laser, optics for guiding and focusing of laser light, - 3D actuators and robots, - controllers and diagnostic systems. 3. Overview of laser sources and their characteristics - Classification, - important parameters for machining and measuring applications, - typical values and comparison. 4. The process of developing laser systems - Conceptualization, - requirements and restrictions, - preliminary design, - modeling and analysis of optical properties, - detailing, - prototype and evaluation. 5. Environmental influences - Impurities, - temperature, - vibrations, - moisture, - laser damage of optical surfaces. 6. Optomechanical characteristics of materials - Spectral transmissivity, reflectivity and absorption of individual types of materials, refractive index, dispersion, thermal expansion, hardness, ... - Examples of transparent materials (properties, machining characteristics), mirror materials, mechanical components, adhesives, seals. 7. Optical aberrations - Physical interpretation, - mathematical description, - techniques of aberrations reduction. 8. Computer design of optical systems 1 - Mathematical description of ray tracing, - the paraxial approximation and the paraxial properties of the optical system 9. Computer design of optical systems 2 - Numerical evaluation of aberrations using the ray tracing method, - characterization of aberrations, - optimization of optical systems. 10. Attachment of optical elements - Analysis of positioning deviations of optical elements, centering techniques for spherical lenses, positioning techniques for prismatic elements - thermal expansion of optical elements and cooling techniques - Examples 11. Adjusting of optical systems - Optical positioning systems, - co-axial alignment between the geometric axis and the laser beam. 12. Laser beam guidance systems
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- Konstrukcijski detajli 13. Sistemi za fokusiranje laserske svetlobe - Optične konfiguracije: enotočkovno, linijsko, ploskovno in večtočkovno fokusiranje. - Soosni optični priključki za nadzorne sisteme - Zasnova in matematični preračuni - Konstrukcijski detajli. 14. Zagotavljanje varnosti laserskih sistemov - Pregled standarda EN 60825 – 4 - Načrtovanje ohišja laserskih sistemov za zagotovite laserskega razreda 1 - Obremenitveni primeri, Pasivna in aktivna zaščita, prebojni testi, dokumentacija. 15. Miniaturizacija laserskih sistemov - Koncepti in pregled značilnih primerov - Razvojni trendi.	- Flying optics, articulated arm, scanner head (1D, 2D and 3D), robot arm integration - Design and mathematical calculations - Construction details 13. Laser focusing systems - Optical configurations: single point, line, center and multi point focusing. - Coaxial optical connectors for monitoring systems - Design and mathematical calculations - Construction details. 14. Ensuring the safety of laser systems - Review of standard EN 60825 - 4 - Design of laser system housing to provide Class 1 laser system - Load cases, Passive and active protection, tests, documentation. 15. Miniaturization of laser systems - Concepts and overview of typical examples - Development trends.
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Temeljna literatura in viri/Readings:

1. E. Kannatey-Asibu, Principles of Laser Materials Processing, Wiley, 2009. [COBISS.SI-ID [11303451](#)]
2. Malacara, Optical Shop Testing, 3rd ed., Wiley, 2007. [COBISS.SI-ID [11174427](#)]
3. J. Hecht: Understanding Lasers: An Entry-Level Guide, 3rd. ed., Wiley-IEEE Press; 2008. [COBISS.SI-ID [10614811](#)]

Cilji in kompetence:

- Cilji:
1. Spoznati zgradbo in delovanje laserskih sistemov.
 2. Razumeti proces razvoja laserskih sistemov.
 3. Spoznati metode načrtovanja in konstruiranja optomehatronskih sistemov.
- Kompetence:
1. S7-MAG in P2-MAG: Usposobljenost za uporabo pridobljenih znanj pri samostojnem reševanju tehničnih problemov na področju laserskih sistemov.
 2. P4-MAG: Sposobnost fizikalnega, matematičnega in numeričnega modeliranja problemov na področju laserskih sistemov z razvito sposobnostjo kritične analize dobljenih rezultatov.
 3. S9-MAG: Usposobljenost za interdisciplinarno povezovanje s strokovnjaki drugih strok na področjih fizike, mehanike, mehatronike in računalništva.

Objectives and competences:

- Objectives:
1. Understand the structure and operation of laser systems.
 2. Understand the process of laser systems development.
 3. To learn the methods of designing and construction of optomechatronic systems.
- Competences:
1. S7-MAG in P2-MAG: The qualification to use the attained knowledge to autonomously solve technical problems in laser systems. And using the fundamental theoretical and applied knowledge, crucial for having command of technical field of laser systems.
 2. P4-MAG: The ability for physical, mathematical and numerical modelling of problems related with laser systems, including a developed ability to critically analyse the results.
 3. S9-MAG: The ability for teamwork and for interdisciplinary networking. Establishing partner relationships with users and other groups. Managerial and organisational skills.

Predvideni študijski rezultati:

Znanja:
Z2: Poglobljeno teoretično, metodološko in analitično znanje z elementi raziskovanja, ki je osnova za zelo zahtevno strokovno delo na področju laserskih sistemov.

Intended learning outcomes:

Knowledge:
Z2: Thorough theoretical, methodological and analytical knowledge with elements of a research work that form a basis for very demanding professional work in the field of laser systems.

Spretnosti: S2.2 Načrtovanje in vodenje delovnega procesa na podlagi ustvarjalnega reševanja problemov, povezanih z lasersko tehniko. S2.3 Sposobnost izvirnih dognanj, stvaritev in kritične presoje na področju laserske tehnike	Skills: S2.2 Planning and managing of the working process on the basis of creative solving of problems that are linked to the teaching and training of the laser systems. S2.3 Ability to acquire original knowledge, creations and critical judgments in the field of laser systems
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Metode poučevanja in učenja: P1 Avditorna predavanja z reševanjem izbranih - za področje značilnih - teoretičnih in praktično uporabnih primerov. P2 Obravnava snovi po urejeni in vnaprej razloženi sistematiki. P3 Avditorne vaje, kjer se teoretično znanje s predavanj podkrepi z računskimi primeri. P4 Laboratorijske vaje z namenskimi didaktičnimi pripomočki (preklopno krmiljenje zapornice, tekočega traku, PID krmiljenje procesa, laserski merilni sistem, laserski obdelovalni sistem). P5 Uporaba študijskega gradiva v obliki e-verzij: predstavitev predavanj, zbirke nalog z vaj, navodil za izvedbo laboratorijskih vaj P14 Virtualni eksperimenti P15 Uporaba video vsebin kot priprava na vaje	Learning and teaching methods: P1 Auditorial lectures with solving selected field-specific theoretical and applied use cases. P2 Presenting the content according to the explained system. P3 Auditorial exercises, in which theoretical content from the lectures is supplemented with practical examples. P4 Laboratory exercises with special-purpose didactic devices (description needs to be added, max. two lines per device). P5 Application of study material (description needs to be added, max. one line per material, e.g. textbook, e-book, printed lecture presentations, etc.). P14 Virtual experiments. P15 Application of videos for preparations to the lectures and exercises.
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Načini ocenjevanja:	Delež/Weight	Assessment:
Teorija (razumevanje konceptov, sistemov, izpeljav in preračunov) – preverjanje v obliki kolokvijev ali izpita ter ustnega zagovora	50,00 %	Theory (understanding of concepts, systems, derivations and calculations) - assesment in the form of colloquiums or exams and oral defense
Vaje (predpriprava, razumevanje, sodelovanje in samostojnost) – preverjanje v obliki ustnih zagovorov na vsakokratni laboratorijski vaji	50,00 %	Exercises (preparation, understanding, cooperation and independence) - assesment in the form of oral defenses at each laboratory exercise

Ocenjevalna lestvica:	Grading system:
5 - 10, pri čemer velja, da je pozitivna ocena od 6 - 10	5 - 10, a student passes the exam if he is graded from 6 to 10

Reference nosilca/Lecturer's references:

Matija Jezeršek:

- JEZERŠEK, Matija**, MOLAN, Katja, TERLEP, Saša, LEVIČNIK HOFFERLE, Špela, GAŠPIRC, Boris, LUKAČ, Matjaž, STOPAR, David. The evolution of cavitation in narrow soft-solid wedge geometry mimicking periodontal and peri-implant pockets. Ultrasonics Sonochemistry. Mar. 2023, vol. 94, [article no.] 106329, str. 1-12, ilustr. ISSN 1350-4177.
<https://www.sciencedirect.com/science/article/pii/S135041772300041X>, <https://repozitorij.uni-lj.si/IzpisGradiva.php?id=144444>, DOI: 10.1016/j.ultsonch.2023.106329. [COBISS.SI-ID [141487619](#)]
- VELLA, Daniele, MRZEL, Aleš, DRNOVŠEK, Aljaž, SHVALYA, Vasy, **JEZERŠEK, Matija**. Ultrasonic photoacoustic emitter of graphene-nanocomposites film on a flexible substrate. Photoacoustics. Dec. 2022, vol. 28, str. 1-10, ilustr. ISSN 2213-5979.
<https://www.sciencedirect.com/science/article/pii/S2213597922000787>, <https://repozitorij.uni-lj.si/IzpisGradiva.php?id=142079>, DOI: 10.1016/j.pacs.2022.100413. [COBISS.SI-ID [126257667](#)]
- JEZERŠEK, Matija**, LUKAČ, Nejc, LUKAČ, Matjaž. Measurement of simulated debris removal rates in an artificial root canal to optimize laser-activated irrigation parameters. Lasers in surgery and medicine. Mar. 2021, vol. 53, iss. 3, str. 411-417, ilustr. ISSN 0196-8092.

<https://onlinelibrary.wiley.com/doi/full/10.1002/lsm.23297>, DOI: 10.1002/lsm.23297. [COBISS.SI-ID [22013443](#)]

4. LUKAČ, Matjaž, OLIVI, Giovanni, CONSTANTIN, Mihnea, LUKAČ, Nejc, **JEZERŠEK, Matija**. Determination of optimal separation times for dual-pulse SWEEPS laser-assisted irrigation in different endodontic access cavities. *Lasers in surgery and medicine*. Sept. 2021, vol. 53, iss. 7, str. 998-1004, ilustr. ISSN 0196-809 <https://onlinelibrary.wiley.com/doi/10.1002/lsm.23357>, DOI: 10.1002/lsm.23357. [COBISS.SI-ID [40611843](#)]
5. VELLA, Daniele, TAŠIČ MUC, Blaž, LUKAČ, Nejc, KOS, Matjaž, DRNOVŠEK, Aljaž, **JEZERŠEK, Matija**. Microstructured optoacoustic lens of black-TiO_x for focused ultrasound and confined cavitation bubbles. V: *European Conference on Biomedical Optics 2021 : ECBO : proceedings : 20-24 June 2021, Munich, Germany*. [S. l.]: OSA, 2021. Str. 1-3, ilustr. ISBN 978-1-943580-95-8. <https://www.osapublishing.org/viewmedia.cfm?uri=ECBO-2021-EM1A.32&seq=0>. [COBISS.SI-ID [77675267](#)]