# UČNI NAČRT PREDMETA/COURSE SYLLABUS

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| **Predmet:** | LASERSKA TEHNIKA |
| **Course title:** | LASERS AND LASER APPLICATIONS |

| **Študijski programi in stopnja** | **Študijska smer** | **Letnik** | **Semestri** |
|---|---|---|---|
| Strojništvo, tretja stopnja, doktorski | Proizvodno inženirske znanosti, kibernetika in mehatronika (smer) | | Celoletni |

**Univerzitetna koda predmeta/University course code:** 7304

| **Predavanja** | **Seminar** | **Vaje** | **Klinične vaje** | **Druge oblike študija** | **Samostojno delo** | **ECTS** |
|---|---|---|---|---|---|---|
| 90 | | | | | 160 | 10 |

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| **Nosilec predmeta/Lecturer:** | Janez Diaci, Matija Jezeršek |

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| **Izvajalci predavanj:** | Janez Diaci, Matija Jezeršek |
| **Izvajalci seminarjev:** | |
| **Izvajalci vaj:** | |
| **Izvajalci kliničnih vaj:** | |
| **Izvajalci drugih oblik:** | |
| **Izvajalci praktičnega usposabljanja:** | |

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| **Vrsta predmeta/Course type:** | Izbirni predmet /Elective course |

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| **Jeziki/Languages:** | Predavanja/Lectures: | Slovenščina, Angleščina |
| | Vaje/Tutorial: | Slovenščina, Angleščina |

| **Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:** | **Prerequisites:** |
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| Veljajo splošni pogoji za doktorski študij. | General prerequisites for the third level studies. |

| **Vsebina:** | **Content (Syllabus outline):** |
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| Osnove laserske fizike:<br>Izbrane teme iz klasične optike. Nelinearna optika, generacija harmonskih frekvenc. Novi laserski viri: aktivne snovi, tehnike črpanja, resonatorji in kvaliteta žarka, oblikovanje žarka, metode za doseganje kratkih in ultrakratkih bliskov.<br>Teoretični opis vodenja svetlobe po optičnih vodnikih. Eno- in večrodovna optična vlakna. Vlakna za prenos velikih moči. Nelinearni pojavi v optičnih vlaknih.<br>Interakcija med lasersko svetlobo in snovjo:<br>Procesi interakcije. Snovne lastnosti (optične, termodinamske, mehanske). Osnovni mehanizmi termičnih laserskih obdelovalnih procesov. Atermalno procesiranje. Asistenca plinov. Optodinamika.<br>Laserski obdelovalni procesi:<br>Lasersko rezanje in varjenje. Laserska ablacija. Lasersko vrtanje. Lasersko čiščenje. Lasersko označevanje in | Fundamentals of laser physics:<br>Selected topics in classical optics. Non-linear optics, harmonic frequency generation. Novel laser sources: active media, pumping techniques, resonators and beam quality, beam shaping, methods for generation of short and ultra-short laser pulses.<br>Theoretical description of light propagation in optical waveguides. Single-mode and multi-mode optical fibers. High power optical fibers. Non-linear effects in optical fibers.<br>Laser light – matter interaction<br>Interaction processes:<br>Material properties (optical, thermodynamic, mechanical). Basic mechanisms of thermal laser processing. Athermal processing. Gas assistance. Optodynamics.<br>Laser processing: |

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| graviranje. Lasersko dolbenje.Laserske mikroobdelave v elektroniki in pri izdelavi mikromehanskih komponent. Lasersko upogibanje. Laserska izdelava prototipov. Diagnostika laserskih obdelovalnih procesov. Modeliranje laserskih obdelovalnih procesov.<br>Laserske merilne metode:<br>Lasersko merjenje razdalj, pomikov, kotov, profilov in 3D oblike teles. Laserska triangulacija. Laserska interferometrija. Lasersko dopplersko merjenje hitrosti.<br>Senzorji z optičnimi vlakni:<br>Intenzitetni senzorji. Senzorji na osnovi fazne detekcije.<br>Vlakenski laserji:<br>Fizikalne lastnosti dopiranih optičnih vlaken. Vlakenski laserji velikih moči. Zgradba in delovanje. Metode za doseganje (ultra-) kratkih bliskov in velikih povprečnih moči. Nove valovne dolžine v IR, vidnem in UV področju. Prednosti in omejitve - primerjava s klasičnimi trdninskimi in plinskimi laserji. Oblikovanje in vodenje žarka. | Laser cutting and welding. Laser ablation. Laser drilling. Laser cleaning. Laser marking and engraving. Laser scribing. Laser micro-processing in electronics and in manufacturing of micromechanical components. Laser forming. Laser-based technologies for rapid prototyping. Laser processing diagnostics. Modeling of laser manufacturing processes.<br>Laser based measurements:<br>Laser measurement of distance, displacement, angle, profile, and 3D shape of objects. Laser triangulation. Laser interferometry. Laser Doppler anemometry and velocimetry.<br>Optical fiber sensors:<br>Intensity sensors. Sensors based on phase detection.<br>Fiber lasers:<br>Physical properties of doped optical fibers. High power fiber lasers. Structure and operation. Methods for generation of (ultra-) short laser pulses and high average power beams. Novel wavelengths in IR, visible and UV spectral ranges. Advantages and limitations – comparison to classical solid-state and gas lasers. Beam shaping and delivery. |

**Temeljna literatura in viri/Readings:**


[1] Das, P: Lasers and Optical Engineering, Springer-Verlag, Berlin, 1991.
[2] Smith, F.G., King, T.A., Wilkins, D.: Optics and photonics, Chichester, John Wiley&Sons, 2007
[3] Allmen, M. von: Laser-beam interactions with materials.- Berlin [etc.]: Springer, 1987
[4] Schuoecker, D.: High power lasers in production engineering, London, Imperial College Press, 1999
[5] Steen, W.M.: Laser material processing, London, Springer Verlag, 2003
[6] Ion, J.C.: Laser processing of engineering materials, Oxford, Elsevier Butterworth-Heinemann, 2005
[7] Gasvik, K.J.: Optical metrology, Chichester, John Wiley &Sons, 1995
[8] J.A. Buck, Fundamentals of Optical Fibers, 2nd edition, Wiley 2004
[9] D.A. Krohn, Fiber optic sensors, Instrument society of America, 1988
[10] L.N. Durvasula, Fiber Lasers: Technology, Systems, And Applications, SPIE-International Society for Optical Engine 2005


| **Cilji in kompetence:** | **Objectives and competences:** |
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| Glavni cilj tega predmeta je vpeljati študente v razumevanje fizikalnih osnov in značilnosti laserjev in interakcije med lasersko svetlobo in snovjo. Poudarek bo dan pomenu značilnosti laserjev za različne industrijske aplikacije. Ob zaključku predmeta naj bi študenti poznali napredne eksperimentalne prijeme in bili kompetentni za samostojno raziskovalno in razvojno delo na področju laserske tehnike. Usposobljeni naj bi bili tudi za razvoj laserskih obdelovalnih in merilnih sistemov v industriji in drugih dejavnostih. | The main goal of this course is to introduce engineers to the physical fundamentals and characteristics of laser sources and laser light-matter interaction. The importance of different laser properties for various industrial applications will be emphasised. At the end of the course, students should be familiar with advanced experimental techniques and be competent for conducting individual reseach in the area of lasers and laser applications. They will also acquire the ability to perform the development and control of laser material processing and measurement systems in industry and medicine. |

| **Predvideni študijski rezultati:** | **Intended learning outcomes:** |
|---|---|
| Glavni cilj tega predmeta je vpeljati študente v razumevanje fizikalnih osnov in značilnosti laserjev in interakcije med lasersko svetlobo in snovjo. Poudarek bo dan pomenu značilnosti laserjev za različne industrijske aplikacije. Ob zaključku predmeta naj bi študenti poznali napredne eksperimentalne prijeme in bili kompetentni za | The main goal of this course is to introduce engineers to the physical fundamentals and characteristics of laser sources and laser light-matter interaction. The importance of different laser properties for various industrial applications will be emphasised. At the end of the course, students should be familiar with advanced |

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| **Metode poučevanja in učenja:** | **Learning and teaching methods:** |
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| Predavanja, laboratorijske vaje, seminarsko delo, e-izobraževanje, konzultacije. Seminarsko delo v čim večji meri navezujoče se na področje doktorskega raziskovanja. Študij z uporabo priporočene literature. | Lectures, laboratory practice & seminar work, e-education, consulting. The seminar work is related, as much as possible, to the student's doctoral research field. Study on a recommended literature basis. |

| **Načini ocenjevanja:** | **Delež/Weight** | **Assessment:** |
|---|---|---|
| Način (seminar, naloge, ustni izpit) • Seminar ( 40%) • Naloge ( 30%) • Ustni izpit ( 30%) | | Method (seminar, assignments, oral examination): • seminar (40%) • assignments (30%) • oral examination (30%) |

**Reference nosilca/Lecturer's references:**

**prof.dr. Janez DIACI**

PAVLOVČIČ, Urban, **DIACI, Janez**, MOŽINA, Janez, JEZERŠEK, Matija. Wound perimeter, area, and volume measurement based on laser 3D and color acquisition. *BioMedical engineering online*, ISSN 1475-925X, Apr. 2015, vol. 14, f. 1-15, ilustr., doi: 10.1186/s12938-015-0031-7.

BOSIGER, Georgije, PERHAVEC, Tadej, **DIACI, Janez**. A method for optodynamic characterization of erbium laser ablation using piezoelectric detection. *Strojniški vestnik*, ISSN 0039-2480, Mar. 2014, vol. 60, no. 3, str. 172-178, ilustr., doi: 10.5545/sv-jme.2013.1077.

GREGORČIČ, Peter, **DIACI, Janez**, MOŽINA, Janez. Two-dimensional measurements of laser-induced breakdown in air by high-speed two-frame shadowgraphy. *Applied physics. A, Materials science & processing*, ISSN 0947-8396, 2013, vol. 112, iss. 1, str. 49-55, ilustr., doi: 10.1007/s00339-012-7173-2.

BOSIGER, Georgije, PERHAVEC, Tadej, MARINČEK, Marko, **DIACI, Janez**. Method for optodynamic source localization during Er:YAG laser ablation. *Journal of biomedical optics*, ISSN 1083-3668, Oct. 2013, vol. 18, iss. 10, str. 100505-1-100505-3, ilustr., doi: 10.1117/1.JBO.18.10.100505.

KUŠČER, Lovro, **DIACI, Janez**. Measurements of erbium laser-ablation efficiency in hard dental tissues under different water cooling conditions. *Journal of biomedical optics*, ISSN 1083-3668, Oct. 2013, vol. 18, no. 10, str. 1-10, ilustr., doi: 10.1117/1.JBO.18.10.108002.

**izr.prof.dr. Matija JEZERŠEK**

GREGORČIČ, Peter, LUKAČ, Nejc, MOŽINA, Janez, JEZERŠEK, Matija. In vitro study of the erbium:yttrium aluminum garnet laser cleaning of root canal by the use of shadow photography. *Journal of biomedical optics*, ISSN 1083-3668, Jan. 2016, vol. 21, iss. 1, str. 1-7, ilustr., doi: 10.1117/1.JBO.21.1.015008.

GREGORČIČ, Peter, ZADRAVEC, J., MOŽINA, Janez, JEZERŠEK, Matija. Optodynamic energy conversion efficiency during laser ablation on metal surfaces measured by shadow photography. *Applied physics. A, Materials science & processing*, ISSN 0947-8396, Oct. 2014, vol. 117, iss. 1, str. 353-357, ilustr., doi: 10.1007/s00339-014-8412-5.

NOVAK, Boštjan, MOŽINA, Janez, JEZERŠEK, Matija. 3D laser measurements of bare and shod feet during walking. *Gait & posture*, ISSN 0966-6362. [Print ed.], Mar. 2014, vol. 40, issue 1, str. 87-93, ilustr., doi: 10.1016/j.gaitpost.2014.02.015.

POVŠIČ, Klemen, FLEŽAR, Matjaž, MOŽINA, Janez, JEZERŠEK, Matija. Laser 3-D measuring system and real-time visual feedback for teaching and correcting breathing. *Journal of biomedical optics*, ISSN 1083-3668, Mar. 2012, vol. 17, iss. 3, str. [1-7], ilustr., doi: 10.1117/1.JBO.17.3.036004. **5.** GORKIČ, Aleš, JEZERŠEK, Matija, MOŽINA, Janez, DIACI, Janez. Measurement of weldpiece distortion during pulsed laser welding using rapid laser profilometry. *Science and technology of welding and joining*, ISSN 1362-1718, 2006, letn. 11, št. 1, str. 48-56. http://dx.doi.org/10.1179/174329306X77065.