UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Senzorji in senzorske tehnologije
Course title:	Sensors and Sensor Technologies

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Senzorske tehnologije, 3. stopnja	/	1	1
Sensor Technologies, 3rd cycle	/	1	1

Vrsta predmeta / Course type	Obvezni / Mandatory
Univerzitetna koda predmeta / University course code:	ST3-893

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike študija	Samost. delo Individ. work	ECTS
15	**15**			**15**	**105**	**5**

**Navedena porazdelitev ur velja, če je vpisanih vsaj 15 študentov. Drugače se obseg izvedbe kontaktnih ur sorazmerno zmanjša in prenese v samostojno delo. / This distribution of hours is valid if at least 15 students are enrolled. Otherwise the contact hours are linearly reduced and transfered to individual work.*

Nosilec predmeta / Lecturer:	Prof. dr. Barbara Malič Prof. dr. Uroš Cvelber Prof. dr. Marina Dermastia Prof. dr. Metka Filipič Prof. dr. Milena Horvat Prof. dr. Đani Juričič Prof. dr. Mihael Mohorčič Prof. dr. Gregor Papa Doc. dr. Hana Uršič Doc. dr. Matjaž Vencelj Prof. dr. Aleksander Zidanšek

Jeziki / Languages:	**Predavanja / Lectures:**	Slovenski, angleški / Slovenian, English
	Vaje / Tutorial:	-

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
Zaključen študij druge stopnje naravoslovne ali tehniške smeri ali zaključen študij drugih smeri z dokazanim poznavanjem osnov področja predmeta (pisna dokazila, pogovor)	Completed second cycle studies in natural sciences or engineering or completed second cycle studies in other fields with proven knowledge of fundamentals in the field of this course (certificates, interview).

Vsebina:	**Content (Syllabus outline):**
Senzorika: sprejemanje in odzivanje na signale iz okolja Karakteristike senzorjev: občutljivost, točnost, stabilnost, območje, ločljivost, selektivnost, drugo. Senzorski materiali: prevodniki, polprevodniki, izolatorji, biološki materiali, tekočine, plini, plazma,	Sensing: receiving and responding to external stimuli Sensor characteristics: sensitivity, accuracy, stability, range, resolution, selectivity, other. Sensor materials: conductors, semiconductors, insulators, biological materials, liquid, gas, plasma,

drugo. Principi pretvorbe signalov: kemijski, električni, magnetni, mehanski odmik, temperatura, toplota, sevanje, svetloba, biološki, drugo. Skupine senzorjev: senzorji fizikalnih / kemijskih veličin, biološki senzorji, senzorji sevanja, multi-senzorji, senzorji za področje okolja in zdravja, drugo. Elektronska vezja: obdelava senzorskega signala, električno napajanje, žično in brezžično povezovanje, drugo. IKT: povezovanje senzorskih naprav v senzorska omrežja in v internet; internet stvari; prenos, shranjevanje in obdelava masovnih podatkov; drugo. Senzorske tehnologije: materiali, izdelava, ohišenje. Nanotehnologije v senzoriki.	other. Transduction principles: chemical, electric, magnetic, mechanical displacement, temperature, heat, radiation, light, biological, other. Groups of sensors: sensors of physical /chemical quantities, biosensors, radiation sensors, multi-sensors, sensors for the environment and health, other. Electronic circuits: sensor signal processing, power supply, wired and wireless connectivity, other. ICT: connecting sensor devices in sensor networks and in the Internet; Internet of things; transfer, storage and processing of mass data; other. Sensor technologies: materials, processing, packaging. Nanotechnology enabled sensors

Temeljni literatura in viri / Readings:

- K. Kalantar-zadeh, Sensors, An Introductory Course, Springer, 2013, ISBN: 978-1-4899-9984-9
- J. Fraden, Handbook of Modern Sensors: Physics, Designs, and Applications, Springer, 3rd ed., 2004, ISBN: 978-1-4939-0040-4
- J.G. Webster, H. Eren (eds.), Measurement, Instrumentation and Sensors Handbook, CRC, 2014, ISBN: 978-1-4398-4883-8
- G. Rao, Optical Sensor Systems in Biotechnology Springer, 2010, ISBN: 978-3642034848
- O. Hersent, D. Boswarthick, O. Elloumi, The Internet of Things: Key Applications and Protocols, John Wiley & Sons Inc, 2012, ISBN: 978-1-1199-9435-0

Ciljani izbor in razprava o aktualnih znanstvenih objavah, predvsem v revijah Science, Nature, Advanced Functional Materials, Sensors, IEEE Internet of Things Journal / Targeted selection and discussion of scientific publications, particularly from Science, Nature, Advanced Functional Materials, Sensors, Biosensors, IEEE Internet of Things Journal, Trends in Plant Sciences, journals in the field of environmental analytical chemistry, and environment and health science

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je seznaniti študente z osnovami senzorskih tehnologij. Študent bo poznal princip delovanja različnih vrst senzorjev, poznal bo omejitve ter prednosti oziroma pomanjkljivosti posameznih vrst senzorjev in njihovega povezovanja. Študent bo spoznal osnovne zahteve pri praktičnih aplikacijah senzorjev. Cilj se navezuje na kompetence: • obvladovanje metod in tehnik, • sposobnost za samostojno in skupinsko raziskovalno in razvojno delo, • sposobnost uporabe znanja v praksi in • delno tudi razvoj integralnega načina mišljenja ter sposobnost za komunikacijo s strokovnjaki drugih disciplin in področij.	The objective of the course is to introduce to students the basics of sensor technologies. The student will understand the principles of operation of different sensors and their interconnection, he will recognize limitations, and advantages / disadvantages. The student will acquire knowledge on basic performance characteristics in various fields of sensor's applications. This objective is related to competences: • mastering of methods and techniques of sensor technologies, • ability to carry out independent as well as team R&D work, • ability to use the knowledge in practice, • and partially also to the development of an

	integral way of thinking and the ability to communicate with experts from other disciplines and fields.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Študent bo na osnovi pridobljenega znanja: • izbral primeren tip senzorja za meritev določenega signala iz okolja, • ocenil prednosti in slabosti posamezne vrste senzorjev, • napovedal omejitve danega senzorja (občutljivost, točnost, ločljivost, selektivnost…), • izbral primerno metodo zajemanja, prenosa in hranjenja podatkov, • znal interpretirati rezultate meritve, • vzpostavil sposobnost komunikacije v angleškem jeziku na področju senzorskih tehnologij.	The student will: • select a suitable sensor for a given stimulus • select the sensing material • judge the advantages / disadvantages of a given group of sensors • forecast limitations of given sensor (sensitivity, accuracy, resolution, selectivity…) • select a suitable data acquisition, transfer and storage system • interpret the results of a measurement • establish the ability to communicate in English in the field of sensor technologies

Metode poučevanja in učenja:	**Learning and teaching methods:**
Interaktivna predavanja Seminar Delo v laboratoriju Konzultacije	Interactive lectures Seminar Work in laboratory Consultations

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Seminarska naloga. Zagovor seminarske naloge, pri katerem študent dokaže osvojitev vseh študijskih izidov z vsaj po enim konkretnim primerom.	50 % 50 %	Seminar work. Defense of the seminar work where the student demonstrates the achievement of all learning outcomes with at least one specific case for each outcome.

Reference nosilca / Lecturer's references:

VOJISAVLJEVIĆ, Katarina, WICKER, Susanne, CAN, Inci, BENČAN, Andreja, BARSAN, Nicolae, MALIČ, Barbara. Nanocrystalline cobalt-oxide powders by solution-combustion synthesis and their application in chemical sensors. *Advanced powder technology*, ISSN 0921-8831. [Print ed.], 2017, vol. 28, no. 4, str. 1118-1128, doi: 10.1016/j.apt.2016.10.029. [COBISS.SI-ID 30119719]

FISHBAIN, Barak, ROBINSON, Johanna A., KOCMAN, David, HORVAT, Milena, et al. An evaluation tool kit of air quality micro-sensing units. *Science of the total environment*, 2017, 575, 639-648, doi: 10.1016/j.scitotenv.2016.09.061.

BLAGUS, Tanja, ŽAGER MARCIUŠ, Valerija, ČEMAŽAR, Maja, SERŠA, Gregor, KAMENŠEK, Urška, ŽEGURA, Bojana, NUNIĆ, Jana, FILIPIČ, Metka. The cell-based biosensor system HepG2CDKN1A-DsRed for rapid and simple detection of genotoxic agents. Biosensors & bioelectronics, ISSN 0956-5663. [Print ed.], Nov. 2014, vol. 61, iss. 11, str. 102-111, doi: 10.1016/j.bios.2014.05.002.

FORTUNA, Carolina, BEKAN, Adnan, JAVORNIK, Tomaž, CERAR, Gregor, MOHORČIČ, Mihael. Software interfaces for control, optimization and update of 5G machine type communication networks. Computer networks : the international journal of computer and telecommunications networking, ISSN 1389-1286. [Print ed.], 2017, vol. 129, part 2, str. 373-383, doi: 10.1016/j.comnet.2017.06.015. [COBISS.SI-ID

30593831]

SILVA, J., FIORI, E., ISAAK, J., LÖHER, Bastian, SAVRAN, Deniz, VENCELJ, Matjaž, WAMERS, F. Temperature gain correction for CsI(Tl) detection systems based on digital pulse shape analysis. Nuclear instruments and methods in physics research. Section A, Accelerators, spectrometers, detectors and associated equipment, ISSN 0168-9002. [Print ed.], 2015, vol. 776, str. 98-106, doi: 10.1016/j.nima.2014.12.064.