UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Izbrana poglavja iz robotike
Course title:	Selected Topics in Robotics

Študijski program in stopnja Study programme and level	Modul Module	Letnik Academic year	Semester Semester
Informacijske in komunikacijske tehnologije, 2. stopnja	Inteligentni sistemi in robotika	1	2
Information and Communication Technologies, 2nd cycle	Intelligent Sytems and Robotics	1	2

Vrsta predmeta / Course type	Izbirni / Elective
Univerzitetna koda predmeta / University course code:	IKT2-617

Predavanja Lectures	Seminar Seminar	Sem. vaje Tutorial	Lab. vaje Laboratory work	Druge oblike	Samost. delo Individ. work	ECTS
30	**30**			**30**	**210**	**10**

**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. Jadran Lenarčič
Jeziki / Languages: Predavanja / Lectures:	slovenščina, angleščina / Slovenian, English
Vaje / Tutorial:	

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**
Zaključen študijski program prve stopnje s področja naravoslovja, tehnike ali računalništva.	Student must complete first-cycle study programmes in natural sciences, technical disciplines or computer science.

Vsebina:	**Content (Syllabus outline):**
1) Uvod V uvodnem delu predmeta se bodo študentje seznanili z vpeljevanjem robotov v industrijo in druge dejavnosti v svetu in specifično v Sloveniji, fleksibilna avtomatizacija v industriji. **2) Direktna kinematika robota** primer direktne kinematike planarnega mehanizma, izpeljava kinematičnih enačb, sistem trigonometričnih enačb, rotacijska matrika, vektorski parametri mehanizma, sinteza kinematičnih enačb za splošni serijski mehanizem.	**1) Introduction** Introduction to robotics, robotics in the world and specifically in Slovenia, advantages of flexible automation in industry. **2) Direct kinematics of robots** Example of direct kinematics of a planar mechanism, development of kinematic equations, system of trigonometric equations, rotation matrix, vector parameters of mechanisms, synthesis of kinematic equations for general serial mechanisms. **3) Inverse kinematics of robots**

3) Inverzna kinematika robota primer inverzne kinematike planarnega mehanizma, problem nerealnih rešitev, problem več realnih rešitev, kinematične enačbe v Jacobijevi obliki, numerično reševanje inverzne kinematike z Newton-Raphsonovo metodo.	Example of inverse kinematics of a planar mechanism, problem of imaginary solutions, problem of multiple solutions, kinematic equations in Jacobian form, Jacobian matrix, inverse kinematics computed by Newton-Raphson numerical method.
4) Dinamični model robota pomen dinamičnega modela, Lagrangeove dinamične enačbe, obravnava enostavnega primera, splošni dinamični model robotskega mehanizma.	**4) Robot dynamic model** Role of dynamic models in robotics, Lagrange dynamic equations, simple examples, general form of a dynamic model
5) Načrtovanje robotskih mehanizmov obravnava matematičnih kriterijev za optimalno sintezo robotskega mehanizma, volumen in oblika delovnega prostora, kinematična prilagodljivost, manipulabilnost.	**5) Design od robot mechanisms** Mathematical criteria for optimum robot design, workspace volume and workspace form, compactness of robot workspace, kinematic flexibility, manipulability and kinematic index
6) Paralelni roboti primeri paralelnih robotov, posebnosti direktne in inverzne kinematike, prednosti in slabosti uporabe paralelnih robotov.	**6) Parallel robots** Examples of parallel robots, characteristics of inverse and direct kinematics computation, advantages and disadvantages of parallel robots relative to robots which posses serial mechanisms.
7) Redundantni roboti primeri kinematične redundance, osnovni principi obravnave redundantnih robotov, pomen kinematične redundance pri načrtovanju in vodenju robotov, primer humanoidne manipulacije	**7) Redundant robots** Examples of kinematic redundancy, basic principles of treating redundant robots, the role of kinematic redundancy in design and control of robot manipulators, examples of humanoid manipulation, human arm as a redundant mechanism in a majority of tasks.

Temeljna literatura in viri / Readings:

- J. Lenarčič, T. Bajd, Robotski mehanizmi, Ljubljana : Fakulteta za elektrotehniko, 2003
- J. J. Craig, Introduction to Robotics (Mechanics and Control), Pearson; 3 edition, 2004
- L. Sciavicco, B. Siciliano, Modelling and Control of Robot Manipulators, CreateSpace Independent Publishing Platform; 2nd edition, 2001

Cilji in kompetence:	**Objectives and competences:**
Cilj predmeta je posredovati temeljno znanje o mehanizmih robotskih manipulatorjev, ki obsega predvsem tematike o gibanju robotov, analizi mehanizmov in njihovem načrtovanju. Predmet obravnava kinematiko in dinamiko robotskih mehanizmov za potrebe razumevanja, vodenja in programiranja njihovega gibanja. V prvem delu predmeta se študentje spoznajo z direktno in inverzno kinematiko, z obravnavo primerov se seznanijo s posebnostmi analitičnega	The goal of the course is to present a basic knowledge on mechanisms of robot manipulators related to their motion, as well as their analysis and synthesis. The most efficient methods of treating direct and inverse kinematics and dynamics for the purpose of understanding, control and programming of robot motion are reported. In the first part of the course, the students learn how to model the inverse and direct kinematics of robot mechanisms and treat different cases of

in numeričnega preračunavanja kinematike serijskih mehanizmov. V drugem delu predmet obravnava dinamiko serijskih mehanizmov in postopek izpeljave dinamičnega modela. V nadaljevanju so predstavljeni pristopi pri načrtovanju najboljših robotskih mehanizmov glede na potrebe, ki izhajajo iz predvidenih opravil. Na koncu predmeta se študentje spoznajo z nekonvencionalnimi robotskimi mehanizmi, kot so paralelni mehanizmi in redundantni mehanizmi.	serial robot mechanisms. The following topic is related to robot dynamics and the basic principles of developing dynamic models are studied. Optimum design of robot mechanisms and different criteria relative to the requirements of robot tasks are also presented. In the end, unconventional robot mechanisms are treated, such as redundant and parallel mechanisms. Students learn the advantages and disadvantages of such mechanisms with respect to standard serial (industrial-type) mechanisms.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Študenti bodo z uspešno opravljenimi obveznostmi tega predmeta pridobili: • Sposobnost analize, sinteze in predvidevanja rešitev ter posledic • Obvladanje raziskovalnih metod, postopkov in procesov, razvoj kritične in samokritične presoje • Sposobnost uporabe znanja v praksi • Avtonomnost v strokovnem delu • Razvoj komunikacijskih sposobnosti in spretnosti, posebej komunikacije v mednarodnem okolju • Etična refleksija in zavezanost profesionalni etiki • Kooperativnost, delo v skupini (in v mednarodnem okolju) • Poznavanje robotskih mehanizmov za namene programiranja in vodenja robotov • Sposobnost vpeljevanja robotov v proizvodne procese • Sposobnost ocenjevanja robotov z vidika gibalnih značilnosti in predvidenih delovnih nalog	Students successfully completing this course will acquire: • An ability to analyse, synthesise and anticipate solutions and consequences • To gain the mastery over research methods, procedures and processes, a development of the critical judgement • An ability to apply the theory in to a practice • An autonomy in the professional work • Communicational-skills development; particularly in international environment • Ethical reflexion and obligation to a professional ethics • Cooperativity, team work (in international environment) • To gain knowledge on robot mechanisms and the ability to program and control robots • Ability to introduce robots in various working processes • Ability to evaluate robot motion and performance characteristics for different tasks

Metode poučevanja in učenja:	**Learning and teaching methods:**
• predavanja • seminarji • laboratorijsko delo	• lectures • seminar work • laboratory work

Načini ocenjevanja:	Delež (v %) / Weight (in %)	**Assessment:**
Seminar	50 %	Seminar
Ustni izpit	50 %	Oral exam

Reference nosilca / Lecturer's references:

- LENARČIČ, Jadran, BAJD, Tadej, STANIŠIĆ, Michael M.. *Robot mechanisms*, (International series on Intelligent systems, control and automation, vol. 60). Dordrecht [etc.]: Springer, cop. 2013. XIV, 333

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- LENARČIČ, Jadran. Some computational aspects of robot kinematic redundancy. V: BARTZ-BEIELSTEIN, Thomas (ur.), et al. Parallel problem solving from nature - PPSN XIII : 13th International Conference, Ljubljana, Slovenia, September 13-17, 2014 : proceedings, (Lecture notes in computer science, ISSN 0302-9743, vol. 8672). Cham [etc.]: Springer. cop. 2014, str. 1-10
- BABIČ, Mitja, VERTECHY, Rocco, BARSELLI, G., LENARČIČ, Jadran, PARENTI-CASTELLI, Vincenzo, VASSURA, G. An electronic driver for improving the open and closed loop electro-mechanical response of dielectric elastomer actuators. Mechatronics, ISSN 0957-4158. [Print ed.], 2010, vol. 20, no. 2, str. 201-212. http://dx.doi.org/10.1016/j.mechatronics.2009.11.006, doi: 10.1016/j.mechatronics.2009.11.006.
- GAMS, Andrej, IJSPEERT, Auke Jan, SCHAAL, Stefan, LENARČIČ, Jadran. On-line learning and modulation of periodic movements with nonlinear dynamical systems. Autonomous robots, ISSN 0929-5593. [Print ed.], 2009, vol. 27, no. 1, str. 3-23.
- BABIČ, Jan, BOKMAN, Lim, OMRČEN, Damir, LENARČIČ, Jadran, PARK, F. C. A biarticulated robotic leg for jumping movements : theory and experiments. Journal of mechanisms and robotics, ISSN 1942-4302, 2009, vol. 1, no. 1, str. 011013-1-011013-9.