ROBOTSKI SISTEMI - PAP

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Robotski sistemi - PAP
Course title:	ROBOTIC SYSTEMS - PAP
Članica nosilka/UL Member:	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semestri	Izbirnost
Strojništvo - projektno aplikativni program, prva stopnja, visokošolski strokovni	Mehatronika (smer)	3. letnik	1. semester	obvezen

Univerzitetna koda predmeta/University course code:	0563956
Koda učne enote na članici/UL Member course code:	3073-V

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			40	4

Nosilec predmeta/Lecturer:	Rok Vrabič
Vrsta predmeta/Course type:	Izbirni strokovni predmet/Elective specialised course

Jeziki/Languages:	Predavanja/Lectures:	Slovenščina
	Vaje/Tutorial:	Slovenščina

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

Izpolnjevanje pogojev za vpis v Visokošolski strokovni študijski program I. stopnje Strojništvo - Projektno aplikativni program.	Meeting the enrollment conditions for the MECHANICAL ENGINEERING - Project Oriented Applied Programme.

Vsebina:	**Content (Syllabus outline):**
1. Predavanje: Uvod □ Predstavitev predmeta □ Uvod v robotiko □ Predstavitev tipov in delitve industrijskih robotov □ Pregled področij uporabe industrijskih robotov 2. Predavanje: Koordinatni sistemi v robotiki □ Rotacije □ Homogena transformacija □ Koordinatni sistemi industrijskih robotov (globalni, uporabnikov, vrha, sklepov) □ Postavitev koordinatnih sistemov na krmilniku 3. Predavanje: Opis robotskih rok □ Denavit-Hartenbergov zapis □ Denavit-Hartenbergovi parametri □ Obravnava primerov 4. Predavanje: Kinematika robotov □ Uporaba direktne kinematika □ Načini gibanja □ Uporaba inverzne kinematika □ Vpliv singularnosti na kinematiko 5. Predavanje: Trajektorije □ Opis trajektorij □ Izvajanje gibanja po trajektoriji □ Upoštevanje omejitev pri gibanju 6. Predavanje: Robotski senzorji □ Kodirniki in tahogeneratorji □ Inercialne merilne enote □ Senzorji sile in navora □ Kamere in globinske kamere 7. Predavanje: Robotski aktuatorji □ Servo motorji □ Robotska prijemala □ Primeri pogosto uporabljenih rešitev 8. Predavanje: Krmiljenje □ Zaprtozančno krmiljenje v robotiki □ Krmiljenje položaja	1. Lecture: Introduction □ Course overview □ Introduction to robotics □ Overview of industrial robot types □ Overview of industrial robot use cases 2. Lecture: Coordinate systems in robotics □ Rotations □ Homogeneous transformation □ Coordinate systems of industrial robots (global frame, user frame, end-effector and joint frames) □ Setting coordinate systems on robot controllers 3. Lecture: Robotic arm description □ Denavit-Hartenberg notation □ Denavit-Hartenberg parameters □ Examples 4. Lecture: Robot kinematics □ Using direct kinematics □ Motion modes □ Using inverse kinematics □ The effect of singularities on kinematics 5. Lecture: Trajectories □ Describing trajectories □ Execution of trajectory following □ Handling movement constraints 6. Lecture: Robotic sensors □ Encoders and tachometers □ Inertial measurement units □ Force and torque sensors □ Cameras and depth cameras 7. Lecture: Robotic actuators □ Servo motors □ Robotic grippers □ Examples of commonly used solutions 8. Lecture: Control □ Closed loop control in robotics □ Position control □ Torque control

□ Krmiljenje navora 9. Predavanje: Programiranje □ Principi programiranja robotskih manipulatorjev □ Programiranje z učno enoto □ Programski jeziki v industrijski robotiki 10. Predavanje: Integracija □ Integracija z drugimi sistemi □ Robotski komunikacijski protokoli □ Tipi vhodov in izhodov krmilnikov □ Programiranje vhodno-izhodnih operacij na krmilniku 11. Predavanje: Varnost □ Delovno območje robota □ Opredelitev mej in con delovanja □ Standardi na področju varnosti □ Analiza pogostih vzrokov za nesreče 12. Predavanje: Vgradnja in vzdrževanje □ Vgradnja v industrijska okolja □ Težave zaradi vibracij, ki nastanejo kot posledica gibanja □ Vzdrževanje robotov □ Poraba energije 13. Predavanje: Izbira robotskih sistemov □ Specifikacije robotov □ Izbira robota glede na delovno območje □ Izbira robota glede na aplikacijo □ Preračun rentabilnosti 14. Predavanje: Industrijske aplikacije: Manipulacija objektov □ SCARA roboti □ Robotske roke in prijemala □ Preračun obremenitev □ Primeri 15. Predavanje: Druge industrijske aplikacije robotov □ Robotsko varjenje □ Robotsko barvanje □ Robotske obdelave □ Uporaba robotov v kontroli kakovosti	9. Lecture: Programming □ Principles of robotic manipulator programming □ Programming using teach penadant □ Programming languages in industrial robotics 10. Lecture: Integration □ Integration of robotic controllers with external systems □ Communication protocols in robotics □ Inputs and outputs of controllers □ Programming input-output operations on controllers 11. Lecture: Safety □ Robot workspace □ Safety limits and safety zones □ Safety standards □ Analysis of common accident causes 12. Lecture: Installation and maintenance □ Installation in industrial environments □ Problems, related to vibration, caused by robot motion □ Robot maintenance □ Energy consumption 13. Lecture: Selection of robotic systems □ Robot specifications □ Selection based on workspace □ Selection based on application □ Calculation of profitability 14. Lecture: Industrial applications: Object manipulation □ SCARA robots □ Articulated robots and grippers □ Load calculation □ Examples 15. Lecture: Other industrial robot applications □ Robotic welding □ Robotic painting □ Robotic machining Using robots in quality control

Temeljna literatura in viri/Readings:

Peter Corke: Robotics, Vision and Control, Springer-Verlag Berlin Heidelberg, 2011

Tadej Bajd, Matjaž Mihelj, Marko Munih: Introduction to Robotics, Springer

Dordrecht Heidelberg New York London, 2013 J. Norberto Pires: Industrial Robots Programming, Springer Science+Business Media, 2007 Thomas R. Kurfess: Robotics and Automation Handbook, CRC Press, 2005 B.S. Dhillon: Robot System Reliability and Safety, CRC Press, 2015

Cilji in kompetence:	**Objectives and competences:**
Cilji: Spoznati delovanje industrijskih robotov. Spoznati upravljanje in programiranje industrijskih robotov. Spoznati načine integracije industrijskih robotov z drugimi sistemi. Spoznati standarde in principe za zagotavljanje varnosti pri delu z industrijskimi roboti. Kompetence: S2-PAP + P7-PAP: Sposobnost upravljanja in programiranja industrijskih robotov S10-PAP + P9-PAP: Sposobnost integracije industrijskih robotov z drugimi sistemi S15-PAP: Sposobnost varnega dela z industrijskimi roboti	Cilji: Understaing the operation of industrial robots. Understanding how to control and program industrial robots. Understanding robot integration with other industrial systems. Understanding standards and principles for ensuring safe operation of robots. Competences: S2-PAP + P7-PAP: The ability to control and program industrial robots. S10-PAP + P9-PAP: The ability to integrate industrial robots with external systems S15-PAP: The ability to ensure safety of industrial robot operation

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanja: Z1: Predmet je namenjen spoznavanju robotskih sistemov in njihove uporabe v industrijskih aplikacijah. Obravnavani so robotski manipulatorji (robotske roke). S pridobljenimi kompetencami so študenti sposobni varnega upravljanja in programiranja industrijskih robotov ter integracije z drugimi sistemi. Spretnosti: S1.1: Uporaba in programiranje industrijskih robotov s pomočjo učnih enot in namenskih programskih jezikov. S1.2: Načrtovanje in izvedba integracije industrijskih robotov z drugimi sistemi	Learning outcomes: Z1: The course objective is to provide basic knowledge about robotic systems and their applications in industrial environments. The course is focused on articulate robots (robotic arms). The acquired competences allow students to safely control, program, and integrate industrial robots. Skills: S1.1: Usage and programming of industrial robots with teach pendants and specific programming languages. S1.2: Planning and executing integration of industrial robots with external

na osnovi povezovanja robotskih krmilnikov.	systems using inputs/outputs of robotic controllers.

Metode poučevanja in učenja:	**Learning and teaching methods:**
P1 Avditorna predavanja z reševanjem izbranih - za področje značilnih - teoretičnih in praktično uporabnih primerov. P2 Obravnava snovi po urejeni in vnaprej razloženi sistematiki. P4 Laboratorijske vaje z namenskimi didaktičnimi pripomočki: industrijskimi roboti, prenosnimi računalniki, namensko programsko opremo. P8 Izdelava in predstavitev aplikativnih seminarskih nalog. P11 Uporaba izvršljivih knjig	P1 Formal lectures with domain-specific theoretical and practical examples. P2 Contents treated in orderly and pre-explained systematic manner. P4 Laboratory work with dedicated teaching aids (industrial robots, mobile robots, laptops, domain-specific software). P8 Design and presentation of applicative seminar papers. P11 Use of executable notebooks.

Načini ocenjevanja:	**Delež/ Weight**	**Assessment:**
Teoretične vsebine (predavanja), preverjane pisno	50,00 %	Theory (lectures) graded with written exams
Praktične vsebine (vaje), preverjane pisno	50,00 %	Practical work (tutorials) graded with written exams

Reference nosilca/Lecturer's references:

Rok Vrabič:

VRABIČ, Rok, KOZJEK, Dominik, BUTALA, Peter. Knowledge elicitation for fault diagnostics in plastic injection moulding : a case for machine-to-machine communication. CIRP annals, 66/1:433-436, 2017.

ŠKULJ, Gašper, **VRABIČ, Rok**, BUTALA, Peter, SLUGA, Alojzij. Decentralised network architecture for cloud manufacturing. International journal of computer integrated manufacturing, 30/4/5:395-408, 2017.

MAKINDE, O. A., MPOFU, Khumbulani, **VRABIČ, Rok**, RAMATSETSE, B. I. A bio-inspired approach for the design of a multifunctional robotic end-effector customized for automated maintenance of a reconfigurable vibrating screen. Robotics and biomimetics, 4/1:1-29, ISSN 2197-3768, 2017.

BUTALA, Peter, **VRABIČ, Rok**, ŠKULJ, Gašper, OOSTHUIZEN, Gert. Robotics competitions as motivator for project oriented learning in mechatronics. V: RobMech 2013 : proceedings, 6th Robotics and Mechatronics Conference - RobMech 2013, 30 & 31 October 2013, Durban, South Africa, 140-145. IEEE. 2013.

VRABIČ, Rok, ERKOYUNCU, John, BUTALA, Peter, ROY, Rajkumar. Digital twins : understanding the added value of integrated models for through-life engineering

services. V: Proceedings of the 7th International Conference on Through-life Engineering Services (Procedia manufacturing, 16:139-146, 2018.