

# ROBOTSKI SISTEMI - PAP

## UČNI NAČRT PREDMETA/COURSE SYLLABUS

<b>Predmet:</b>	Robotski sistemi - PAP
<b>Course title:</b>	ROBOTIC SYSTEMS - PAP
<b>Članica nosilka/UL Member:</b>	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	obvezna

<b>Univerzitetna koda predmeta/University course code:</b>	0563956
<b>Koda učne enote na članici/UL Member course code:</b>	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

<b>Nosilec predmeta/Lecturer:</b>	Rok Vrabič
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<b>Vrsta predmeta/Course type:</b>	Izbirni strokovni predmet/Elective specialised course
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<b>Jeziki/Languages:</b>	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.
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## Vsebina:

1. Predavanje: Uvod <input type="checkbox"/> Predstavitev predmeta <input type="checkbox"/> Uvod v robotiko <input type="checkbox"/> Predstavitev tipov in delitve industrijskih robotov <input type="checkbox"/> Pregled področij uporabe industrijskih robotov 2. Predavanje: Koordinatni sistemi v robotiki <input type="checkbox"/> Rotacije <input type="checkbox"/> Homogena transformacija <input type="checkbox"/> Koordinatni sistemi industrijskih robotov (globalni, uporabnikov, vrha, sklepov) <input type="checkbox"/> Postavitev koordinatnih sistemov na krmilniku 3. Predavanje: Opis robotskih rok <input type="checkbox"/> Denavit-Hartenbergov zapis <input type="checkbox"/> Denavit-Hartenbergovi parametri <input type="checkbox"/> Obravnavna primerov 4. Predavanje: Kinematika robotov <input type="checkbox"/> Uporaba direktne kinematika <input type="checkbox"/> Načini gibanja <input type="checkbox"/> Uporaba inverzne kinematika <input type="checkbox"/> Vpliv singularnosti na kinematiko 5. Predavanje: Trajektorije <input type="checkbox"/> Opis trajektorij <input type="checkbox"/> Izvajanje gibanja po trajektoriji <input type="checkbox"/> Upoštevanje omejitev pri gibanju 6. Predavanje: Robotski senzorji <input type="checkbox"/> Kodirniki in tahogeneratorji <input type="checkbox"/> Inercialne merilne enote <input type="checkbox"/> Senzorji sile in navora <input type="checkbox"/> Kamere in globinske kamere 7. Predavanje: Robotski aktuatorji <input type="checkbox"/> Servo motorji <input type="checkbox"/> Robotska prijemala <input type="checkbox"/> Primeri pogosto uporabljenih rešitev 8. Predavanje: Krmiljenje <input type="checkbox"/> Zaprtzoančno krmiljenje v robotiki <input type="checkbox"/> Krmiljenje položaja	
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## Content (Syllabus outline):

1. Lecture: Introduction <input type="checkbox"/> Course overview <input type="checkbox"/> Introduction to robotics <input type="checkbox"/> Overview of industrial robot types <input type="checkbox"/> Overview of industrial robot use cases 2. Lecture: Coordinate systems in robotics <input type="checkbox"/> Rotations <input type="checkbox"/> Homogeneous transformation <input type="checkbox"/> Coordinate systems of industrial robots (global frame, user frame, end-effector and joint frames) <input type="checkbox"/> Setting coordinate systems on robot controllers 3. Lecture: Robotic arm description <input type="checkbox"/> Denavit-Hartenberg notation <input type="checkbox"/> Denavit-Hartenberg parameters <input type="checkbox"/> Examples 4. Lecture: Robot kinematics <input type="checkbox"/> Using direct kinematics <input type="checkbox"/> Motion modes <input type="checkbox"/> Using inverse kinematics <input type="checkbox"/> The effect of singularities on kinematics 5. Lecture: Trajectories <input type="checkbox"/> Describing trajectories <input type="checkbox"/> Execution of trajectory following <input type="checkbox"/> Handling movement constraints 6. Lecture: Robotic sensors <input type="checkbox"/> Encoders and tachometers <input type="checkbox"/> Inertial measurement units <input type="checkbox"/> Force and torque sensors <input type="checkbox"/> Cameras and depth cameras 7. Lecture: Robotic actuators <input type="checkbox"/> Servo motors <input type="checkbox"/> Robotic grippers <input type="checkbox"/> Examples of commonly used solutions 8. Lecture: Control <input type="checkbox"/> Closed loop control in robotics <input type="checkbox"/> Position control <input type="checkbox"/> Torque control	
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<ul style="list-style-type: none"> <li>□ Krmiljenje navora</li> <li>9. Predavanje: Programiranje <ul style="list-style-type: none"> <li>□ Principi programiranja robotskih manipulatorjev</li> <li>□ Programiranje z učno enoto</li> <li>□ Programski jeziki v industrijski robotiki</li> </ul> </li> <li>10. Predavanje: Integracija <ul style="list-style-type: none"> <li>□ Integracija z drugimi sistemi</li> <li>□ Robotski komunikacijski protokoli</li> <li>□ Tipi vhodov in izhodov krmilnikov</li> <li>□ Programiranje vhodno-izhodnih operacij na krmilniku</li> </ul> </li> <li>11. Predavanje: Varnost <ul style="list-style-type: none"> <li>□ Delovno območje robota</li> <li>□ Opredelitev mej in con delovanja</li> <li>□ Standardi na področju varnosti</li> <li>□ Analiza pogostih vzrokov za nesreče</li> </ul> </li> <li>12. Predavanje: Vgradnja in vzdrževanje <ul style="list-style-type: none"> <li>□ Vgradnja v industrijska okolja</li> <li>□ Težave zaradi vibracij, ki nastanejo kot posledica gibanja</li> <li>□ Vzdrževanje robotov</li> <li>□ Poraba energije</li> </ul> </li> <li>13. Predavanje: Izbira robotskih sistemov <ul style="list-style-type: none"> <li>□ Specifikacije robotov</li> <li>□ Izbira robota glede na delovno območje</li> <li>□ Izbira robota glede na aplikacijo</li> <li>□ Preračun rentabilnosti</li> </ul> </li> <li>14. Predavanje: Industrijske aplikacije: Manipulacija objektov <ul style="list-style-type: none"> <li>□ SCARA roboti</li> <li>□ Robotske roke in prijemala</li> <li>□ Preračun obremenitev</li> <li>□ Primeri</li> </ul> </li> <li>15. Predavanje: Druge industrijske aplikacije robotov <ul style="list-style-type: none"> <li>□ Robotsko varjenje</li> <li>□ Robotsko barvanje</li> <li>□ Robotske obdelave</li> <li>□ Uporaba robotov v kontroli kakovosti</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>9. Lecture: Programming <ul style="list-style-type: none"> <li>□ Principles of robotic manipulator programming</li> <li>□ Programming using teach penadant</li> <li>□ Programming languages in industrial robotics</li> </ul> </li> <li>10. Lecture: Integration <ul style="list-style-type: none"> <li>□ Integration of robotic controllers with external systems</li> <li>□ Communication protocols in robotics</li> <li>□ Inputs and outputs of controllers</li> <li>□ Programming input-output operations on controllers</li> </ul> </li> <li>11. Lecture: Safety <ul style="list-style-type: none"> <li>□ Robot workspace</li> <li>□ Safety limits and safety zones</li> <li>□ Safety standards</li> <li>□ Analysis of common accident causes</li> </ul> </li> <li>12. Lecture: Installation and maintenance <ul style="list-style-type: none"> <li>□ Installation in industrial environments</li> <li>□ Problems, related to vibration, caused by robot motion</li> <li>□ Robot maintenance</li> <li>□ Energy consumption</li> </ul> </li> <li>13. Lecture: Selection of robotic systems <ul style="list-style-type: none"> <li>□ Robot specifications</li> <li>□ Selection based on workspace</li> <li>□ Selection based on application</li> <li>□ Calculation of profitability</li> </ul> </li> <li>14. Lecture: Industrial applications: Object manipulation <ul style="list-style-type: none"> <li>□ SCARA robots</li> <li>□ Articulated robots and grippers</li> <li>□ Load calculation</li> <li>□ Examples</li> </ul> </li> <li>15. Lecture: Other industrial robot applications <ul style="list-style-type: none"> <li>□ Robotic welding</li> <li>□ Robotic painting</li> <li>□ Robotic machining</li> </ul> </li> </ul> <p>Using robots in quality control</p>
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### **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:**

#### **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

### **Objectives and competences:**

#### **Cilji:**

Understanding 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:**

#### **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

### **Intended learning outcomes:**

#### **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.
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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.

P4 Laboratorijske vaje z namenski didaktičnimi pripomočki: industrijski roboti, prenosnimi računalniki, namensko programsko opremo.

P8 Izdelava in predstavitev aplikativnih seminarskih nalog.

P11 Uporaba izvršljivih knjig

### Learning and teaching methods:

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).