Faculty of Mechanical Engineering / MECHATRONICS / ROBOTICS

Course:	ROBOTICS			
Course ID	**Course status**	**Semester**	**ECTS credits**	**Lessons** (Lessons+Exercises+Laboratory)
12461	Mandatory	3	6	2+1+1
Programs	MECHATRONICS			
Prerequisites	None.			
Aims	The main objective of this course is to study the principles of robotics and the concepts of advanced robotics, including kinematics, control and planning of robots.			
Learning outcomes	Upon completion of this course, the student should be able to program and design robots, including the specification of sensors and actuators required for robot movement.			
Lecturer / Teaching assistant	Prof. dr Radoš Bulatović, mr Aleksandar Tomović			
Methodology	Lectures, exercises, laboratory exercises, and project-oriented learning.			
Plan and program of work				
Preparing week	Preparation and registration of the semester			
I week lectures	Introduction to robotics. Definition, generations, types and characteristics of robots. Robot modeling: kinematic chains, industrial robots. Robot configuration. Workspace.			
I week exercises	Introduction to robotics. Definition, generations, types and characteristics of robots. Robot modeling: kinematic chains, industrial robots. Robot configuration. Workspace.			
II week lectures	Actuators and drive systems in robots: requirements, rectangular coordinates, electric actuators (DC, AC, 3-phase AC, servo motors, stepper motors); pneumatic actuators, hydraulic actuators; gear systems (harmonic drive, etc.).			
II week exercises	Actuators and drive systems in robots: requirements, rectangular coordinates, electric actuators (DC, AC, 3-phase AC, servo motors, stepper motors); pneumatic actuators, hydraulic actuators; gear systems (harmonic drive, etc.).			
III week lectures	Sensors, internal: motion control loop, position and speed measurement; sensors and principles: encoder (incremental, absolute, multi-turn devices, SSI interfaces), resolver, tachogenerator.			
III week exercises	Sensors, internal: motion control loop, position and speed measurement; sensors and principles: encoder (incremental, absolute, multi-turn devices, SSI interfaces), resolver, tachogenerator.			
IV week lectures	Kinematic analysis of robots: direct kinematics. Internal and external coordinates. Solving direct kinematic problems. Algorithm for solving direct kinematic problems. Denavit-Hartenberg. Examples.			
IV week exercises	Kinematic analysis of robots: direct kinematics. Internal and external coordinates. Solving direct kinematic problems. Algorithm for solving direct kinematic problems. Denavit-Hartenberg. Examples.			
V week lectures	Kinematic analysis of robots: inverse kinematics. Jacobian matrix. Examples. Singularity phenomenon.			
V week exercises	Kinematic analysis of robots: inverse kinematics. Jacobian matrix. Examples. Singularity phenomenon.			
VI week lectures	Colloquium I.			
VI week exercises	Colloquium I.			
VII week lectures	Controlling robots: basic concepts; control modes: axis movement, Cartesian movement, movement in different coordinate systems.			
VII week exercises	Controlling robots: basic concepts; control modes: axis movement, Cartesian movement, movement in different coordinate systems.			
VIII week lectures	Control of robots: PTP (point-to-point) - point-by-point (synchronous/asynchronous), CP (Continuous Path) - along a continuous line (linear, circular, curved line); movement profiles: profile of speed, acceleration.			
VIII week exercises	Control of robots: PTP (point-to-point) - point-by-point (synchronous/asynchronous), CP (Continuous Path) - along a continuous line (linear, circular, curved line); movement profiles: profile of speed, acceleration.			
IX week lectures	Control of robots: interpolation, interpolation time cycle TIPO, working modes, interfaces (digital, analog, serial, field bus), teach box.			
IX week exercises	Control of robots: interpolation, interpolation time cycle TIPO, working modes, interfaces (digital, analog, serial, field bus), teach box.			

X week lectures	Robot programming: programming modes (online, offline); teach-in, playback, off-line programming (programming with a text editor, macro programming, programming using icons, graphical programming with simulation)
X week exercises	Robot programming: programming modes (online, offline); teach-in, playback, off-line programming (programming with a text editor, macro programming, programming using icons, graphical programming with simulation)
XI week lectures	Robot Programming: Robot Simulation: Simulation Systems, RRS (Real Robot Simulation) Initiative, Calibration Issues, Planning. Robot languages, the structure of robot programs: main and subprograms, program functions, examples.
XI week exercises	Robot Programming: Robot Simulation: Simulation Systems, RRS (Real Robot Simulation) Initiative, Calibration Issues, Planning. Robot languages, the structure of robot programs: main and subprograms, program functions, examples.
XII week lectures	Robots with external sensors, robot vision: sensor hierarchy, adaptive functions, principles of sensor selection: for object search (tactile), distance reading, contour tracking, speed, object recognition, force and torque.
XII week exercises	Robots with external sensors, robot vision: sensor hierarchy, adaptive functions, principles of sensor selection: for object search (tactile), distance reading, contour tracking, speed, object recognition, force and torque.
XIII week lectures	Integration of robots and sensors: mechanical integration, interfacing and processing of sensor data: feedback and feedforward strategy, response time. Examples: object search strategy, contour tracking strategy; force/torque sensing in assembly robot vision: object recognition, position and orientation detection in handling applications.
XIII week exercises	Integration of robots and sensors: mechanical integration, interfacing and processing of sensor data: feedback and feedforward strategy, response time. Examples: object search strategy, contour tracking strategy; force/torque sensing in assembly robot vision: object recognition, position and orientation detection in handling applications.
XIV week lectures	Application of robots in production: transfer and handling of material, loading and unloading, processing, spot and continuous welding, spray painting, assembly and inspection. The future of robots.
XIV week exercises	Application of robots in production: transfer and handling of material, loading and unloading, processing, spot and continuous welding, spray painting, assembly and inspection. The future of robots.
XV week lectures	Colloquium II.
XV week exercises	Colloquium II.
Student workload	

Per week	**Per semester**
6 credits x 40/30=8 hours and 0 minuts 2 sat(a) theoretical classes 1 sat(a) practical classes 1 excercises **4 hour(s) i 0 minuts** of independent work, including consultations	Classes and final exam: **8 hour(s) i 0 minuts x 16 =128 hour(s) i 0 minuts** Necessary preparation before the beginning of the semester (administration, registration, certification): **8 hour(s) i 0 minuts x 2 =16 hour(s) i 0 minuts** Total workload for the subject: **6 x 30=180 hour(s)** Additional work for exam preparation in the preparing exam period, including taking the remedial exam from 0 to 30 hours (remaining time from the first two items to the total load for the item) **36 hour(s) i 0 minuts** Workload structure: **128 hour(s) i 0 minuts (cources), 16 hour(s) i 0 minuts (preparation), 36 hour(s) i 0 minuts (additional work)**
Student obligations	Mandatory attendance of classes and creation of a laboratory project.
Consultations	
Literature	1. Craig, J.J., Introduction to Robotics: Mechanics and Control, 3rd ed. Pearson Education, 2005 2. Howie C., et al., Principles of Robot Motion: Theory, Algorithms, and Implementation, MIT Press, 2005 3. Saeed, B. N., Introduction to Robotics: Analysis, Systems, Applications, Prentice Hall, 2001
Examination methods	Two colloquiums of 40 points each, a total of 80 points; Project assignment: 20 points. A passing grade is obtained if at least 50 points are accumulated cumulatively.
Special remarks	
Comment	

Grade:	F	E	D	C	B	A
Number of points	less than 50 points	greater than or equal to 50 points and less than 60 points	greater than or equal to 60 points and less than 70 points	greater than or equal to 70 points and less than 80 points	greater than or equal to 80 points and less than 90 points	greater than or equal to 90 points