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Freie Universität Bozen
Libera Università di Bolzano
Università Liedia de Bulsan

Syllabus
Course description

Course title	Industrial Automation and Digital Manufacturing
Course code	47557
Scientific sector	ING-IND/13 (Modul 1) + ING-IND/16 (Modul 2)
Degree	Master in Industrial Mechanical Engineering
Semester	2
Year	I
Academic year	2024/25
Credits	10
Modular	Yes

Total lecturing hours	Modul 1 – 24 hrs, Modul 2 - 24 hrs
Total lab hours	Modul 1 – 24 hrs, Modul 2 – 24 hrs
Total exercise hours	
Attendance	Recommended (especially for exercise hours)
Prerequisites	None
Course page	https://www.unibz.it/en/faculties/engineering/master-industrial-mechanical-engineering/course-offering/?academicYear=2024

Specific educational objectives	The course belongs to the class of characterizing courses in the Master in Industrial Mechanical Engineering. It aims at teaching both scientific foundations and practical methods and helps to develop specific professional skills in the domains of industrial robotics and digital manufacturing. Students will learn, in **Module 1 "Mechatronics and Robotics**", fundamental concepts and methodologies for understanding and modelling mechatronic systems and industrial robots, i.e. mandatory concepts and skills for the development of digital models and twins as well as for the kinematics and dynamics evaluation and control; then, they will acquire fundamental knowledge and competences on how to simulate and program industrial robots by means of exercises and practical activities. **Module 2 "Digital Manufacturing and Simulation"** provides the basics in cyber-physical production systems, data- driven production, industrial internet of things, digital twin technology and simulation methodologies. Theoretical foundations will focus on the design, planning and implementation of connected machines and resources in production as well as the fundamentals of simulation for production and logistics. In addition to theoretical models and methods the practical use of cyber-physical systems as well as specific simulation software in the production environment is treated by means of exercises

	and practical case studies. Smart Mini Factory lab will serve as laboratory for both the modules.

Module 1	**Mechatronics and Robotics**
Lecturer	Dr. Andrea Giusti
Teaching language	English
Office hours	By appointment
Teaching assistant (if any)	tbd
Office hours	/
List of topics covered	The module will cover: • introduction to mechatronics and robotic systems; • overview of industrial, mobile and service robots • industrial Robotics: 3D Kinematics and statics - Direct and inverse kinematics. - Application to industrial manipulators. - Differential Kinematics, singularities and statics. - Robot Dynamics (hints). • Introduction to Robot Awareness: proprioceptive and exteroceptive sensors. • Simulation, motion planning and programming of industrial robotic systems.
Teaching format	The topics are presented by the professor by means of Power Point presentations or the blackboard. Practical parts and lab activities/exercises are planned also in the Smart Mini Factory learning factory laboratory

Module 2	**Digital Manufacturing and Simulation**
Lecturer	Dr. Matteo De Marchi
Scientific sector of the lecturer	ING-IND/16
Teaching language	English
Office hours	By appointment
Teaching assistant (if any)	
Office hours	/
List of topics covered	The course covers the following topics: <u>Lecture:</u> Part 1) SIMULATION • Fundamentals of simulation modelling • Principles, methods and procedures for implementing simulation studies • Fields of application for simulation • Software tools for simulation Part 2) DIGITAL MANUFACTURING • Introduction to data-driven production • Industrial Internet of Things

	• Data Analytics and retrofitting of legacy systems • Work 4.0 and digital worker assistance systems • Digital twins in manufacturing • Manufacturing cybersecurity Simulation Lab: 1. Introduction to FlexSim 2. Data analysis and distributions 3. Case study modelling (production plant and/or logistics systems modelling and simulation) 4. Advanced features and Virtual Reality practice Industrial Internet of Things (IoT) Lab: 1. Introduction to the case study 2. Retrofitting of legacy equipment 3. Hardware set-up and software coding 4. Data extraction and analysis 5. KPI visualization on IoT-platform
Teaching format	Frontal lectures and exercises in Smart Mini Factory Lab

Learning outcomes	Knowledge and understanding Module 1: The students will know the most important concepts about: • mechatronic and robotic fundamentals (definitions, components and elements) • the principles of simulating and programming an industrial robotic systems • 3D mechanisms from a kinematic point of view Module 2: The student knows the basics and advanced features of simulation modelling and analysis as well as the current methods and tools for digitalization in manufacturing. Applying knowledge and understanding The student applies and practices theoretical contents through exercises, case studies and project work. Theory contents are practiced through exercises using practical examples. From Module 1, the students will know how to treat a robotic system form a kinematic (position and speed) and static point of view as well as how to set-up a robotic simulator and motion control program. In Module 2 the students develop independently a simulation model for given case studies out from the production and logistics environment. In a second lab they practice IIoT and handling data with IoT platforms. Presentation techniques are trained using equipment such as flipcharts and power point presentations. Making judgements

	Module 1: The student will be able to make judgments selecting the suitable robotic system for a practical industrial solution. Module 2: The student judges the use of appropriate methods, models and systems for simulation and Industrial IoT. Students are able to judge and interpret simulation results and data extracted from production and to use them for derivate measures for optimization. Communication skills • Ability to present the acquired knowledge and competences with a proper language • Ability to express concepts with the field related technical terminology Learning skills The students learn both by frontal teaching (theory part) as well as by exercises in the classroom and in the Smart Mini Factory lab (practical exercises). The students will be able to enlarge their knowledge through self-study and consultation of scientific and technical documentation
Assessment	Module 1: Knowledge and understanding: written exam/reports Applying knowledge and understanding: group work Making judgements: group work Communication skills: group work Learning skills: group work, written/oral exam or presentation Module 2: Knowledge and understanding: written exam Applying knowledge and understanding: assignments in lab exercises Making judgements: assignments in lab exercises Communication skills: presentation of results of lab exercises Learning skills: lab exercises, written/oral exam Written exam means exam with review questions and exercises. Assignments in lab exercises means case study work and subsequent presentation of the results.
Assessment language	English
Evaluation criteria and criteria for awarding marks	Final single grade by arithmetic average of the grade in Module 1 and Module 2. Module 1: The final mark will be obtained combining the evaluations of the written test/reports and of the oral examination/presentation. Module 2: The grade is calculated 50% from the results of

	the written exam and 50% from the results of the project work performed in the Simulation lab and IIoT lab. Criteria for the evaluation of the written examination: completeness and correctness of the answers. Criteria for the evaluation of the project work / case study: accuracy and completeness as well as creativity in structuring of the proposed solution, the quality of the results and quality of presentation. In case a written exam cannot be held due to "force majeure" such as COVID-19 restrictions, the course responsible reserve the right to hold a written exam via online tools (e.g. OWL) and/or an oral exam with digital communication platforms instead of the written exam.

Required readings	Lecture notes and documents for exercise will be available on the course platform (e.g. Teams, OLE or reserve collections)
Supplementary readings	Module 1: **Siciliano, B., Sciavicco, L., Villani, L., Oriolo, G., Robotics, Modelling, Planning and Control, Springer** **J. Craig, Introduction to Robotics: Mechanics and Control, Pearson Education International** Module 2 **Applied simulation: modeling and analysis using FlexSim** M. Beaversotck, A. Greenwood, W. Nordgren 2017 ISBN : 978-0-9832319-7-4 Available in the unibz library for students of this course Bozen-Bolzano University Library 14-Reference Collection ST 341 F34 B386 **Industrial Internet of Things: Cybermanufacturing Systems** edited by Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat. Serie: Springer Series in Wireless Technology, Available online via unibz library database Springer Link