Course Unit	Cyberphysical Systems			Field of study	Automation		
Master in	Electrical and Computers Engineering			School	School of Technology and Management		
Academic Year	2023/2024	Year of study	1	Level	2-1	ECTS credits	6.0
Type	Semestral	Semester	1	Code	5070-792-1103-00-23		

Workload (hours)	162	Contact hours	T	TP	PL	TC	S	E	OT	O
			-	30	30	-	-	-	-	-

T - Lectures; TP - Lectures and problem-solving; PL - Problem-solving, project or laboratory; TC - Fieldwork; S - Seminar; E - Placement; OT - Tutorial; O - Other

Name(s) of lecturer(s): Paulo Jorge Pinto Leitão, Jose Fernando Lopes Barbosa

Learning outcomes and competences

At the end of the course unit the learner is expected to be able to:
1. Understand the importance if the cyber-physical systems in the 4th industrial revolution context.
2. Obtain knowledge of Industry 3.0, particularly industrial automation technologies, lean manufacturing, Flexible Manufacturing Systems (FMS), Computer Integrated Manufacturing and ISA-95.
3. Understand the characteristics, main design principles and enabling technologies of cyber-physical systems.
4. Know the RAMI 4.0 reference architecture, and the positioning of cyber-physical systems in the 3 dimensions of the RAMI 4.0 model.
5. Obtain knowledge of distributed supervisory control systems using multi-agent systems and service orientation.
6. Obtain knowledge on the digitalization of assets, Digital Twin and Asset Administration Shell (AAS).
7. Model and analyze discrete event-driven systems using Petri nets.
8. Design and implement short cyber-physical system solutions.

Prerequisites

Before the course unit the learner is expected to be able to:
1. Execute operations using Boolean algebra, binary arithmetic and numeration systems.
2. Apply the basic concepts of industrial automation, namely programmable logic controllers.
3. Elaborate computational programs.

Course contents

Introduction to industrial automation systems. Lean manufacturing.
Technologies of industrial automation systems and computer-aided tools. Computer integrated manufacturing and integration of systems. Industry 4.0 and cyber-physical systems. Control and supervision distributed systems. Virtualization of cyber-physical systems. Modeling discrete event-drive system using Petri nets.

Course contents (extended version)

1. Introduction to industrial automation systems
   - Definition, automation types, production types, production activities and manufacturing functions.
   - Mathematical models for manufacturing systems.
2. Lean manufacturing
   - Definition, types of waste, benefits.
   - Analysis of lean techniques, namely Kanban, Poke-Yoke, 5SSs, SMED and Six Sigma.
3. Technologies of industrial automation systems
   - Robotics, numerical control, automatic storage and transport systems.
   - Computational tools to support manufacturing activities (CAD, CAM, CAE, CAPP, etc.).
4. Understanding Industry 3.0
   - Flexible and Reconfigurable Systems.
   - Computer Integrated Manufacturing (CIM).
   - PERA, ISA-95, MES.
   - Vertical and Horizontal Connectivity.
   - Integration of systems and interoperability.
5. Industry 4.0 and cyber-physical systems
   - Concept, characteristics and design principles, benefits.
   - Enabling technologies.
   - Positioning in the RAMI 4.0 model.
   - Human in Industry 4.0.
6. Control and supervision distributed systems
   - Multi-agent systems.
   - Security.
7. Virtualization of cyber-physical systems
   - Eco-systems of digitalized Assets.
   - Asset Administration Shell.
   - Digital Twins.
8. Modeling discrete event-drive system using Petri nets
   - Modeling analysis and requirements. Modeling languages for discrete event-driven systems.
   - Petri nets: definition, symbology, basic rules and properties.
   - Analysis and validation of Petri nets.
   - Temporized Petri nets. High-level Petri nets.

Recommended reading

1. “Computer integrated manufacturing and engineering”, U. Rembold, B. O. Nnaji, Addison-Wesley, 1993.
2. “Introduction to Embedded Systems - A Cyber-Physical Systems Approach”, E. A. Lee and S. A. Seshia, MIT Press, 2014.
3. “Industrie 4.0 - The Reference Architecture Model RAMI 4.0 and the Industrie 4.0”, R. Heidel and M. Hoffmeister, Beuth, 2019.
4. “Applications of Petri Nets in Manufacturing Systems. Modelling, Control and Performance Analysis”, Alan A. Desrochers and Robert Y. Al-Jaar, IEEE Press, 1994.
5. “An Introduction to MultiAgent Systems”, Michael Wooldridge, Second Edition, John Wiley & Sons, 2009.

Teaching and learning methods

Theoretical-practical classes: exposition of the proposed topics, and discussion of selected topics, which enhance the acquisition of transversal skills.
Practical classes: realization of exercises and practical works to help to consolidate the expected learning outcomes. Learning complemented with the development of short projects to be implemented preferentially during the non-presential hours.

Assessment methods

- Alternative 1 - (Regular, Student Worker) (Final, Supplementary, Special)
  - Final Written Exam - 50% (The approval requires the achievement of a minimum score of 35%.)
  - Laboratory Work - 50% (Considers the results obtained in the laboratory works and the participation in the classrooms.)

Language of instruction

Portuguese, with additional English support for foreign students.

Electronic validation

Paulo Jorge Pinto Leitão	José Luís Sousa de Magalhaes Lima	José Carlos Rufino Amaro
01-10-2023	11-10-2023	20-10-2023