Countries	Institutions	Common Module	ECTS
Romania **Poland** **Greece** **France** **Bulgaria**	Military Technical Academy "Ferdinand I" Military University of Technology Hellenic Air Force Academy French Air Force Academy "Vasil Levski" National Military University	**Applied Automation of Engineering Systems** *European Common Technical Semester for Defence and Security*	**3.0**

Service	Minimum Qualification of Instructors
Technical/ALL	• **Officers or civilian Lecturers:** ○ English: Common European Framework of Reference for Languages (CEFR) Level B2 or min. NATO STANAG 6001 Level 3. ○ Expertise in relevant topics. ○ Relevant academic publications.
Language **English**	

Prerequisites for international participants	Goal of the Module
• English: Common European Framework of Reference for Languages (CEFR) Level B1 or NATO STANAG Level 2. • At least 1 year of national (military) higher education. • Basic knowledge in technical systems for security and defence	• Education, discovering and understanding practical principles of control systems and robotics. • Learn about mathematical analysis of linear control systems, stability assessments, control quality, synthesis methods and correction of automation systems' dynamic properties. • Learn about the mathematical description and analysis of robotics systems. • Discover and understand practical matters regarding control and robotics systems.matters regarding control and robotics systems.

Learning outcomes	Know-ledge	• Explain the main concepts of automation and control theory applied in engineering systems. • Identify the main methods for modelling robotic stations, for programming robots and designing and controlling them.
	Skills	• Measure the properties of control systems and robots, conducting time and frequency analysis. • Design, model and simulate practical control systems and robotic stations, using engineering programming software (environments).
	Respon-sibility and autonomy	• Analyse the control systems and robotics devices in manufacturing processes. • Estimate the need and goal of using automation and robotics systems in practical applications.

Verification of learning outcomes:

- **Observation**: Throughout the Module students will meet with the systems applications, and they will discuss the given topics in the plenary and present teamwork results. During this workshop, students will be evaluated to verify their competencies.
- **Project**: Teamwork project and project defence.
- **Test**: Final examination at the end of the module.

Module details

Main Topic	Recom-mended WH	Details
Mathematical Models of Automation Systems	6	Creating linear models of control systems such as the transfer-function model, frequency model, state-space model, time and frequency characteristics, characteristics of fundamental dynamic elements, and block diagrams. The classes aim to model, design and simulate some control systems in MATLAB software. • **Lecture (2h):** *- The mathematical description, design, and analysis of automation systems.* • **Applications (4h):** *- Designing and simulation of some control systems using MATLAB software with specialised toolboxes.*
Design the Controller and Synthesis of the Automation Control Systems	6	The types, characteristics, and parameters of the classical controllers. Ziegler-Nichols controller design method. Root locus design method. The classes aim to model, design, and simulate some control systems in MATLAB software. • **Lecture (2h):** *- The design and synthesis issues of the controller in control systems.* • **Applications (4h):** *- The simulation and analysis of some control systems with various controllers using MATLAB software.*
Modelling, Control Design and Experiment of 2 DOF/3 DOF Helicopter	6	Modelling, designing and testing helicopter models mounted on a fixed base with two propellers driven by DC motors. During the model movement, all rotation angles are measured by high-resolution encoders. Laboratories are done by using a graphical programming environment and real-time embedded controllers. • **Lecture (2h):** *- The modelling and design of control systems of the helicopter model.* • **Applications (4h):** *- The laboratory research of the 2 DOF Helicopter model with controller* *- The laboratory research of the 3 DOF Helicopter model with controller*
Modelling, Control Design and Experiment of Inverted Pendulum/ Rotary Double Inverted Pendulum	6	Modelling, designing, and implementing a state-feedback control system that will balance the pendulum in the upright vertical position to a commanded rotary arm angle. Laboratories are done by using a graphical programming environment and real-time embedded controllers. • **Lecture (2h):** *- The modelling and design of a state-feedback control system of the inverted pendulum.* • **Applications (4h):** *- The experimental research on the inverted pendulum.* *- The experimental research on the rotary double inverted pendulum.*

Module details

Main Topic	Recom-mended WH	Details
Introduction to manipulators and robot systems (construction and control)	6	Presentation of the construction of selected types of manipulators, controllers, and control panels. Configuration of the robot system. Presentation of the robot control methodology. • **Lecture (2h):** - *The design, model, and simulate robotic stations.* • **Applications (4h):** - *The experimental research on selected manipulators and robot systems.*
Environments for offline programming of robots	6	Overview of selected environments for offline programming of robots. Acquainting the methodology of offline robot programming. Configuration of the robot system in offline mode. Programming the manipulator movement for a selected task in a virtual environment. Conducting a simulation and analysis of the implemented process. • **Lecture (2h):** - *The overview of environments for robots offline programming.* • **Applications (4h):** - *Programming the manipulator movement for an appointed task in a virtual environment.* - *The experimental research on selected manipulators.*
Selected online robot control systems	6	Overview of selected online robot control systems. Acquainting the methodology of online robot programming. Configuration of the robot system in online mode. Programming the manipulator movement for a selected task in a real environment. Running a real robot and analysing the process being carried out. • **Lecture (2h):** - *The overview of environments for robots online programming.* • **Applications (4h):** - *Programming the manipulator movement for a selected task in a virtual environment.* - *The experimental research on selected manipulators.*
Total WH	**42**	
Additional hours (WH) to increase the learning outcomes		
Self-Studies and syndicate work	33	• Enhancing knowledge by studying specific documents. • Preparation for the group project. • Teamwork for the group project. • Those hours comprise the work of students in laboratories and exercises to improve skills and consolidate knowledge.
Total WH	**75**	

BIBLIOGRAPHY:

1. L.C. Westphal.: Handbook of control system engineering, Springer Science and Business Media, New York, 2001.
2. L.C. Westphal.: Sourcebook of control systems engineering, Springer Science and Business Media, New York, 1995.
3. Shimon Y. Nof.: Springer Handbook of Automation, Springer Dordrecht Heidelberg London New York, 2009
4. Norman S. Nise. Control Systems Engineering. John Wiley & Sons, Inc., 2008.
5. K. J. Åström and K. Furuta. Swinging up a pendulum by energy control. 13th IFAC World Congress, 1996.
6. Panasiuk J., Kaczmarek W. Robotization of production processes, PWN, Warsaw 2019.
7. J. Apkarian, M. Lévis, C. Fulford, "Laboratory Guide, 2 DOF Helicopter Experiment for LabVIEW Users", Quanser Inc., 2012
8. J. Apkarian, M. Lévis, C. Fulford, "Laboratory Guide, 3 DOF Helicopter Experiment for LabVIEW Users", Quanser Inc., 2012
9. J. Apkarian, M. Lévis, "Laboratory Guide, Rotary Double Inverted Pendulum Experiment for LabVIEW Users", Quanser Inc., 2012
10. J. Apkarian, P. Karam, M. Lévis, "Student Workbook Inverted Pendulum Experiment for LabVIEW Users", Quanser Inc., 2012
11. ABB, User Guide.
12. RobotStudio User Guide.
13. FANUC, User Guide.
14. Roboguide, User Guide.

List of Abbreviations:

B1, B2 .... CEFR Levels

CEFR .... Common European Framework of Reference for Languages

ECTS .... European Credit Transfer and Accumulation System

WH .... Working Hour