COURSE OUTLINE

(1) GENERAL

SCHOOL	School of Science		
ACADEMIC UNIT	Department of Digital Industry Technologies		
LEVEL OF STUDIES	Postgraduate (MSc on Robotics and Industrial Control)		
COURSE CODE	**001**	**SEMESTER**	1st
COURSE TITLE	Cooperative Robotic Systems		
INDEPENDENT TEACHING ACTIVITIES if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits	**WEEKLY TEACHING HOURS**		**CREDITS**
Lectures	3		8
Total	3		8
COURSE TYPE *special background, specialised general knowledge, skills development*	Specialization Course		
PREREQUISITE COURSES:	---		
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek and/or English		
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes, under conditions		
COURSE WEBSITE (URL)	https://ric-en.dind.uoa.gr/el/studies/curriculum/1st_semester/cooperative_robotic_systems/		

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

Aim of the course is to familiarize students with control tools for cooperative robotic systems, being comprised by groups of similar and/or different types of robots. Groups in various interconnection architectures and fields of application are studied in the framework of Industry 4.0. Emphasis is placed on 3d printing, manufacturing processes and load transfer applications. Upon successful completion of the course, students will be able to:

- Understand the principles of kinematic and dynamic analysis of cooperative robotic systems,
- Understand and compose architectural structures for information exchange and control of groups of cooperative robotic systems,
- Develop control software for the implementation of robotic works of autonomous robotic systems
- Compose robotic works and schedule robotic tasks of cooperative robotic systems, using advanced control tools, and
- Control and schedule works of cooperative robotic systems, using tools of game theory.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology
Adapting to new situations Decision-making
Working independently Team work
Project planning and management Respect for difference and multiculturalism Respect for the natural environment
Showing social, professional and ethical responsibility and sensitivity to gender issues

Working in an international environment Working in an interdisciplinary environment Production of new research ideas	*Criticism and self-criticism* *Production of free, creative and inductive thinking* *……* *Others…* *…….*
Search for, analysis and synthesis of data and information, with the use of the necessary technology, Decision-making, Working independently, Teamwork, Project planning and management, Criticism and self-criticism, Production of free, creative and inductive thinking.	

(3) SYLLABUS

Kinematics, dynamics, and control of the individual participating robotic systems. Cooperative Robotic Systems (CRS) comprising heterogeneous robots. Networks of sensors and actuators. Types of graphs determining the access to the measurable data and their impact on the control actions and the system's efficient operation. Architecture of CRS: centralized systems and distributed systems. Matrix analysis of CRS graphs and Laplacian. Distributed controlled for CRS. Communications in CRS. Efficient information sharing in CRS. CRS in the framework of Industry 4.0. Cooperative multi-robot systems constraint analysis (connectivity, force constraints and position constraints). Applications to cooperative 3D printing systems. CRS towards load manipulation and machining. Robotic works and robotic tasks in CRS (Scheduling, Planning, Programming and Software tools). Control and Programming of CRS tasks in the Game Theory framework.

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face to face, Synchronous and Asynchronous distance learning
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	Supporting the learning process through • use of an electronic platform for interactive two-way communication and participation, • use of an electronic classroom platform, providing educational material, discussions, announcements, assignments, • e-mail communication, • use of projectors during lectures, • use of software packages for simulation development • use of software packages for control of robotic systems • use of software packages, collecting and exchanging data among robotic systems
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non- directed study according to the principles of the ECTS*	

Activity	***Semester Workload***
Lectures	39
Literature study & analysis	70
Project / Essay writing	91
Course Total	200

STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure* *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other*	The evaluation of postgraduate students and their performance in the course takes place at the end of each semester with written or oral examinations or assignments throughout the semester or can be based on intermediate progress exams, written assignments, laboratory exercises or a combination of all the above. The method of evaluation is defined by the instructor of the course and announced to the students. The language for written and oral examinations is the same with that used for teaching. The

Specifically-defined evaluation criteria are given, and if and where they are accessible to students.	assignments essays may be written in Greek and/or English language. When conducting written or oral examinations as assessment methods, the integrity of the procedure must be ensured. Scoring is done on a scale of 0-10. The results of the examinations are announced by the instructor and sent to the Secretariat of the Postgraduate Program within four weeks at the latest from the examination of the course. The participation rate of exercises, assignments, etc. The final grade of the course is determined by the course instructor and announced to students at the beginning of the semester. Alternative assessment methods may be applied, such as the conduct of written or oral examinations using electronic means, provided that the integrity of the evaluation process is ensured and the provisions of the relevant regulations of the MSc are met. Alternative methods may also be applied for the assessment of students with disabilities and special educational needs following a decision of the Board of Directors and the recommendation of the head of the Department for Disabled Persons and taking into account the relevant instructions of the Accessibility Unit for Students with Disabilities.

(5) ATTACHED BIBLIOGRAPHY

- Suggested bibliography:

1. P. Schleer, Model-Based Versatile Configuration of Cooperative Robotic Systems for Surgery, Shaker Verlag, 2021.
2. P. Matthews and S. Greenspan, Automation and Collaborative Robotics: A Guide to the Future of Work, Apress, 2020.
3. S. Zaidan, A Work-Piece Based Approach for Programming Cooperating Industrial Robots, Herbert Utz Verlag, 2013.
4. F. Zhang and Y. Wang (eds), Trends in Control and Decision-Making for Human–Robot Collaboration Systems, Springer International Publishing, 2017.
5. R. Duro and Y. Kondratenko (eds), Advances in Intelligent Robotics and Collaborative Automation, River Publishers, 2022.
6. J. Liu and J. Wu, Multiagent Robotic Systems, CRC Press, 2018.
7. J. H. Ortiz and R. Vinjamuri (eds), Collaborative and Humanoid Robots, IntechOpen, 2021.
8. E. Kagan, I. Ben-Gal and N. Shvalb (eds.), Autonomous Mobile Robots and Multi-Robot Systems: Motion-Planning, Communication, and Swarming, Wiley, 2019.
9. Y. Yue and D. Wang, Collaborative Perception, Localization and Mapping for Autonomous Systems, Springer Nature Singapore, 2020.
10. M. D . Zivanovic and M. Vukobratovic, Multi-Arm Cooperating Robots: Dynamics and Control, Springer Netherlands, 2006.
11. Shuai Li and Yinyan Zhang, Neural Networks for Cooperative Control of Multiple Robot Arms, Springer Nature Singapore, 2017
12. <Robotic Agents – time delays?>
13. Hajduk, M., Sukop, M., and Haun, M. (2019). Cognitive Multi-agent Systems: Structures, Strategies and Applications to Mobile Robotics and Robosoccer, volume 138. Springer
14. Mesbahi Mehran, Egerstedt Magnus, Graph theoretic methods in multiagent networks, vol. 33, Princeton University Press (2010)
15. M. S. Spong and M. Vidyasagar, Robot Dynamics and Control, Willey, 1989.
16. L. Fuller, Robotics (Introduction, Programming and Projects), Maxwell MacMillan International Editions, 1991.
17. R. N. Jazar, Theory of Applied Robotics: Kinematics, Dynamics, and Control, Springer Science & Business Media, 2010.
18. B. Siciliano and O. Khatib, Springer Handbook of Robotics, Springer International Publishing, 2016.

19. A. J. Kurdila and P. Ben-Tzvi, Dynamics and Control of Robotic Systems, John Wiley & Sons, 2019.
20. P. Corke, Ρομποτική, Όραση και Έλεγχος, Γρηγόριος Χρυσοστόμου Φούντας, 2020.
21. J. J. Craig, Εισαγωγή στη Ρομποτική: Μηχανική και Αυτόματος Έλεγχος, Εκδόσεις Α. Τζιόλα & Υιοί ΑΕ, 2020.
22. B. Siciliano, L. Sciavicco, L. Villani και G. Oriolo, Ρομποτική: Μοντελοποίηση, Σχεδιασμός και Έλεγχος, Γρηγόριος Χρυσοστόμου Φούντας, 2013.
23. Σ. Τζαφέστας, Ρομποτική: Ανάλυση, Έλεγχος, Σχεδιασμός, Προγραμματισμός, Αίσθηση, Σπυρίδων Τζαφέστας, 2003.
24. M. J. Mataric, Βασικές Αρχές Ρομποτικής, Εκδόσεις Κλειδάριθμος ΕΠΕ, 2010.
25. Φ. Ν. Κουμπουλής & Β. Γ. Μέρτζιος, Εισαγωγή στη Ρομποτική, Εκδόσεις Παπασωτηρίου, 2002.
26. Δ. Μ. Εμίρης και Δ. Κουλουριώτης, Ρομποτική, Εκδόσεις Τζιόλα, 2020.
27. Ζ. Δουλγέρη, Ρομποτική: Κινηματική, Δυναμική και Έλεγχος Αρθρωτών Βραχιόνων, Εκδόσεις Κριτική, 2007.
28. Ι. Μπούταλης, Ρομποτική: Ανάλυση, Έλεγχος και Προγραμματισμός Ρομποτικών Χειριστών Σταθερής Βάσης, Εκδόσεις Κρίκος, 2017.

- Relative academic journals:

1. Autonomous Robots, Springer.
2. Frontiers in Robotics and AI, Frontiers.
3. Journal of Field Robotics, Wiley.
4. Journal of Intelligent & Robotic Systems, Springer.
5. Robotics and Automation Letters, Institute of Electrical and Electronics Engineers.
6. Robotics and Automation Magazine, Institute of Electrical and Electronics Engineers.
7. Robotics and Autonomous Systems, Elsevier.
8. Robotics and Computer-Integrated Manufacturing, Elsevier.
9. Soft Robotics, Mary Ann Liebert Inc.
10. The International Journal of Robotics Research, SAGE Journals.
11. Transactions on Medical Robotics and Bionics, Institute of Electrical and Electronics Engineers.
12. Transactions on Robotics, Institute of Electrical and Electronics Engineers.