COURSE OUTLINE: ROBOTICS II

1. GENERAL

SCHOOL	Engineering		
DEPARTMENT	Electrical and Computer Engineering		
LEVEL OF STUDY	Undergraduate		
COURSE UNIT CODE	9.013	**SEMESTER**	9th
COURSE TITLE	**Robotics II**		

COURSEWORK BREAKDOWN	**TEACHING WEEKLY HOURS**	**ECTS Credits**
Theory (Lectures)	3	2.5
Tutorial/Exercises	1	0.5
Laboratory	1	1
TOTAL	**5**	**4**

COURSE UNIT TYPE	Specialized knowledge/Skills development
PREREQUISITES	8.012 – Robotics I
LANGUAGE OF INSTRUCTION/EXAMS	Greek
COURSE DELIVERED TO ERASMUS STUDENTS	No
WEB PAGE (URL)	https://eclass.hmu.gr/courses/ECE209/

2. LEARNING OUTCOMES

Learning Outcomes

- Acquisition of necessary knowledge for the dynamic modeling of robotic systems when they are in free motion or interact with the environment.
- Understanding the concept of robot control and the use of classical controllers used in robotic systems at the torque and velocity levels.
- Acquisition of theoretical background for conducting research on robotic systems.

General Skills

The study and successful completion of the course contribute to the development of general skills related to:

- Research, analysis, and synthesis of data and information, utilizing necessary technologies.
- Promotion of free, creative, and inductive thinking.
- Bridging theoretical knowledge with practical skills.
- Adaptability to new situations.
- Decision-making.

3. SYLLABUS

Theoretical lectures

- Robot dynamics including modeling topics: free motion of articulated robotic arm in space, arm interaction with the environment, cooperation of robotic arms for object manipulation, motion of robotic systems in aquatic environments, and flying robots. Linear and non-linear control methodologies for robotic systems in free motion in space and interaction with the environment. General control scheme and motion controller architecture for joint motion. Controller design in joint space and Cartesian space of the gripper.
- Jacobian matrices of articulated robots. Solution of the inverse kinematics problem at the velocity level. Solution of the problem for redundant robots.
- Body velocity, hybrid velocity, twists, and twist combination. Generalized force-torque.
- Independent control of articulated robotic systems with large gear couplings between actuators-joints and moderate speed response: dynamic characteristics of actuators, analysis of the action of a typical PD and PID position controller, position and trajectory control of joints with force feedback, controller design in state space with state feedback and observers, control with pre-computed system dynamics torques and disturbance compensation.
- Reaching and trajectory tracking control in the task (Cartesian) and joint space of the robot considering robots receiving velocity commands. Closed Loop Inverse Kinematics (CLIK).
- Reaching and trajectory tracking control in the task (Cartesian) and joint space of the robot considering robots receiving torque commands. Inverse dynamic control based on the nonlinear model of the system, feedback linearization methods.
- Lyapunov stability analysis, through asymptotic and exponential stability theorems and LaSalle's theorem.
- Control of robotic arm force, stiffness control, hybrid position-force control. Inverse and forward Jacobian controller, inverse dynamic control in the Cartesian space of the gripper. Implementation methodologies of controllers based on voltage control and torque-current control.

The above topics are supported by a series of exercises presented during theory lectures and applications of the above control methods both in simulation and in real robotic systems. Additionally, students will be assigned projects for the control and dynamic simulation of the analyzed dynamic systems mentioned above.

4. TEACHING METHODS - ASSESSMENT

MODE OF DELIVERY	In-Class Face-to-Face
USE OF INFORMATION AND COMMUNICATION TECHNOLOGY	▪ Use of ICTs in lecturing ▪ Use of ICTs in laboratory sessions ▪ Use of ICTs for the communication with students via the e-class platform
TEACHING ORGANIZATION	see table below
ASSESSMENT METHODS	All announcements for the course regulations and complementary reading material are posted on the course web page. The course grade incorporates the following evaluation procedures: 1. Written examination (70 %) 2. Laboratory reports (30 %)

Method description/Activity	Semester Workload
Lectures	39
Laboratory sessions	13
Report preparation	22
Non-guided personal study	46
Total Hours	**120**

5. RECOMMENDED BIBLIOGRAPHY

-Recommended Bibliography:

- "Rompotiki – Kinimatiki, dinamiki ke elegxos arthroton vrachionon", Z. Doulgeri, Kritiki, 2007. (*in Greek*)
- "Robotics: Modelling, Planning and Control", Siciliano, Sciavicco, Villiani, Oriol, Fountas, 2013. (*in Greek*)
- "Robot Dynamics & Control", M.W. Spong, M. Vidyasagar, John Wiley & Sons, 1989.
- "Introduction to Robotics: Mechanics and Control", Craig J.J., Tziola, 2009. (*in Greek*)

Relevant Scientific Journals:

- IEEE Transactions on Robotics
- IEEE Robotics and Automation Letters
- International Journal of Robotics Research