M092	Elective, III year	**Introduction to Control Theory with Applications**	L	S	E	ECTS
			2	1	2	7

Course objectives. Course objectives are to familiarize students with all the basic building blocks of control theory. The students will understand and be able to analyze system properties important for control (stability, controllability, observability) and to design regulator with desired properties and apply it to a real dynamic system. Theory will be applied to a problem of mobile robots control through simulator training, as well as through work on a real robot.

Course prerequisites. Ordinary differential equation. Embedded Systems.

Syllabus.

1. Introduction to dynamic systems. Linear time invariant (LTI) system.
2. Control objectives. PID regulator. Implementation of PID regulator in discrete time model.
3. Modelling and understanding control settings: example of differential drive wheel robot. Unicycle model.
4. Linearization of nonlinear models.
5. Asymptotic stability. State feedback (closed loop dynamics). Output feedback.
6. Controllability and regulator synthesis by setting the desired eigenvalues (pole placement). Examples: Segway robot model and its controllability.
7. Observability; The separation principle and regulator synthesis.
8. Introduction to hybrid systems: Hybrid automata. Stability. Zeno behavior in hybrid systems. Sliding Mode control and regularization.

EXPECTED LEARNING OUTCOMES

No.	LEARNING OUTCOMES
1.	To demonstrate knowledge and understanding which can serve as the foundation for developing and application of original ideas.
2.	To apply knowledge, understanding and skills in a broad variety of problems in the field of control theory and application to mobile robots.
3.	To integrate new knowledge and problem solving skills in this field.
4.	To be able to present conclusions and findings to experts and laymen based on knowledge and experience.
5.	To apply the acquired skills onto further education in this field.

COUPLING OF THE EXPECTED LEARNING OUTCOMES, TEACHING PROCESS ORGANIZATION AND THE EVALUATION OF THE TEACHING OUTCOMES

TEACHING PROCESS ORGANIZATION	ECTS	EXPECTED LEARNING OUTCOMES **	STUDENT ACTIVITY *	EVALUATION METHOD	SCORE	
					min	max
Lecture attendance	1	1-5	Class atendance, discussion, solving the problems individually and in a team	Lists with signatures, observing the activity during the lectures	0	4
Homework	1	1-4	Solving the problems individually	Grading	12	20
Repeated exams	2	1-4	Preparation for the written exam	Grading	19	38
Final exam	2	1-4	Revising	Oral exam	19	38

Teaching methods and student assessment. Classes are organized through lectures and exercises. During lectures students will be familiarized with basic and important terms and results in control theory. During exercises students apply the acquired abstract knowledge to the concrete problems in mobile robot control via Matlab or Python based simulator, as well as implement the theory on a real mobile robot (Raspberry Pi) constructed by the students. Lectures and exercises are obligatory. Exam will consist of a practical work (project) through which the student have to demonstrate theoretical and practical skills learned. Homework and seminar papers made during the semester will influence the final grade.

Can the course be taught in English: Yes

Basic literature:

1. J. Hespanha, Linear Systems Theory, Princeton University Press, 2009.

Recommended literature:

1. Z. Li, S. S. Ge, Fundamentals in Modeling and Control of Mobile Manipulators, CRC Press, 2013.
2. S. M. Lavelle, Planning Algorithms, Cambridge University Press, 2006.
3. A. Barrera, Advances in Robot Navigation, INTECH Open Access Publisher, 2011.
4. W. E. Dixon, D. M. Dawson, E. Zergeroglu, A. Behal, Nonlinear Control of Wheeled Mobile Robots, Springer, 2001.