SYLLABUS

1. Information regarding the programme

1.1 Higher education institution	**Babeş Bolyai University**
1.2 Faculty	**Faculty of Mathematics and Computer Science**
1.3 Department	**Department of Computer Science**
1.4 Field of study	**Computer Science**
1.5 Study cycle	**Master**
1.6 Study programme / Qualification	**Artificial Intelligence for Connected Industries**

2. Information regarding the discipline

2.1 Name of the discipline (en) (ro)			**Control System Theory and Engineering** **Teoria şi Ingineria Sistemelor de Control**				
2.2 Course coordinator			**Dr. Thu Hang Bui**				
2.3 Seminar coordinator			**Dr. Thu Hang Bui**				
2.4. Year of study	**1**	2.5 Semester	**2**	2.6. Type of evaluation	**E**	2.7 Type of discipline	**Compulsory**
2.8 Code of the discipline		**MME8217**					

3. Total estimated time (hours/semester of didactic activities)

3.1 Hours per week	4	Of which: 3.2 course	2	3.3 seminar/laboratory	1 lab + 1 project
3.4 Total hours in the curriculum	56	Of which: 3.5 course	28	3.6 seminar/laboratory	28
Time allotment:					hours
Learning using manual, course support, bibliography, course notes					30
Additional documentation (in libraries, on electronic platforms, field documentation)					26
Preparation for seminars/labs, homework, papers, portfolios and essays					26
Tutorship					0
Evaluations					12
Other activities:					-

3.7 Total individual study hours	94
3.8 Total hours per semester	150
3.9 Number of ECTS credits	6

4. Prerequisites (if necessary)

4.1. curriculum	• Fundamentals of higher mathematics, especially linear algebra • Fundamentals of signals and systems • Basic design methods for linear time-invariant (LTI) systems in frequency domain
4.2. competencies	• Mathematics (algebra)

5. Conditions (if necessary)

5.1. for the course	•
5.2. for the seminar /lab activities	

6. Specific competencies acquired

Professional competencies	This course provides control theories including linear and non-linear systems in time domain, modern approaches of control-theory-based methods for requirements on safety, sustainability and economic sustainability and economic feasibility of technical products and production plants. Systematic design of model-based controllers in the time domain allows considering of non-linearities and has the potential to achieve significantly improved controller results. On completion of this course, the students will have essential skills for: • Apply the methods of model-based control theory of linear and non-linear systems. • Describe the necessary mathematics and system-theory basics. • Analyze time-continuous systems in the time domain • Categorize systems according to system-theoretic properties • Apply formal methods in order to design controllers in time domain • Apply methods for designing controllers for non-linear systems and are capable of managing its operation
Transversal competencies	CT1. Application of efficient work rules and responsible attitudes towards the scientific domain, for the creative exploitation of one's own potential according to the principles and rules of professional ethics CT2. Efficient conduct of activities organized in an interdisciplinary group and development of empathic capacity of interpersonal communication, networking and collaboration with diverse groups CT3. Use of efficient methods and techniques for learning, information, research and development of abilities for knowledge exploitation, for adapting to the needs of a dynamic society and for communication in a widely used foreign language.

7. Objectives of the discipline (outcome of the acquired competencies)

7.1 General objective of the discipline	• Students will learn linear and non-linear time-continuous systems, their control and feedback control, modern approaches of control-theory-based methods for requirements on safety, sustainability and economic sustainability and economic feasibility of technical products and production plants
7.2 Specific objective of the discipline	In this course, students will learn - Linear and non-linear time-continuous systems in state space - Linearization and general solution of linear differential equations of states - Structural properties of linear time-invariant (LTI) systems in state space (stability, controllability, observability) - Design of state controllers and state observers for linear systems - Analysis of non-linear systems (Lyapunov-stability) - Control and feedback control of non-linear systems

8. Content

8.1 Course	Teaching methods	Remarks
I. Course background - Elements of System Identification - From time to frequency domain. From frequency to time domain - Linear and non-linear time-continuous systems in state space - Linear time-invariant systems. Recap: Laplace transform, analysis of LTI systems II. Continuous-time state-space systems - LTI state-space models - Canonical forms for LTI state-space models - Linear time-varying systems and nonlinear systems III. Discrete-time state-space systems IV. Stability (Lyapunov stability, stability of locally linearized systems, input-output stability) V. Observability and controllability VI. State-feedback control. Output-feedback control. VII. Design of state controllers and state observers for linear systems VIII. Analysis of non-linear systems (Lyapunov-stability) IX. Control and feedback control of non-linear systems	• Exposure: description, explanation, examples, discussion of case studies	

Bibliography

1. B. Friedland, “Control System Design: An Introduction to StateSpace Methods,” Dover Publications, 1986, ISBN: 0-486-44278-0
2. Robert L. Williams II, Douglas A. Lawrence: Linear state-space control systems. John Wiley 2007, ISBN 0-471-73555-8
3. S. Sastry. Nonlinear systems - Analysis, Stability and Control. Springer-Verlag (1999) (and C. Tomlin - slides of the course “Advanced Nonlinear Control”, Stanford University)
4. D.S. Naidu, “Optimal Control Systems” CRC Press, 2002, ISBN: 0-849-30892-5.

8.2 Laboratory	Teaching methods	Remarks

Seminar 1: Control system tutorial using matlab Seminar 2: Canonical forms for LTI state-space models Seminar 3-4: Observability (e.g.: motor driven cart, two-car train). Seminar 5: Kalman filtering Seminar 6-7: Linear Quadratic Regulator	• Explanation, dialogue, debate, group work	
8.3 Project	Teaching methods	Remarks
1. Temperature Control System: - Raspberry Pi Role: Manages the desired temperature (setpoint), displays historical data, and can implement more complex control logic if needed. - Arduino Uno Role: Reads temperature from a sensor (like an LM35DZ) and implements a digital PID controller to regulate a heating or cooling element via PWM. - Concept: The Arduino's internal 10-bit A/D converter measures temperature, and its PWM output controls a transistor to adjust power to the heating element to maintain the setpoint. 2. DC Motor Control: - Raspberry Pi Role: Sends speed commands (setpoints) to the Arduino, logs motor performance, and can implement advanced algorithms like model predictive control (MPC). - Arduino Uno Role: Reads motor speed from an encoder and uses a PID controller to adjust the motor's power, ensuring it reaches and maintains the desired speed. - Concept: The Arduino's micro-controller counter and interrupts help achieve a constant sampling period for accurate PID implementation. 3. Water Level Control: - Raspberry Pi Role: Provides setpoint control and can monitor flow rates and tank levels remotely. - Arduino Uno Role: Reads water level from a sensor, executes a PID algorithm to control a pump or valve, and maintains the desired water level.	Explanation, dialogue, debate, group work	

Bibliography

1. B. Friedland, “Control System Design: An Introduction to StateSpace Methods,” Dover Publications, 1986, ISBN: 0-486-44278-0
2. D.S. Naidu, “Optimal Control Systems” CRC Press, 2002, ISBN: 0-849-30892-5.

9. Corroborating the content of the discipline with the expectations of the epistemic community, professional associations and representative employers within the field of the program

- The course exists in the studying program of all major universities abroad;

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Share in the grade (%)
10.4 Course	- know the basic principles, theory and models in the domain; - apply and understand course concepts	Written exam	60%
10.5 Lab activities	- be able to implement course concepts, models and algorithms	Project and assignments	40%
10.6 Minimum performance standards			
The final grade should be minimum 5 and consists of: a. score obtained in the written exam in proportion of 60% b. research project 40%			

Date	Signature of course coordinator	Signature of seminar coordinator
19.09.2025	Dr. Thu Hang Bui	Dr. Thu Hang Bui

Date of approval	Signature of the head of department
....	Assoc.Prof. dr. Adrian Sterca