Syllabus

1. Data about the program of study

1.1 Institution	Technical University of Cluj-Napoca
1.2 Faculty	Automation and Computer Science
1.3 Departament	Automation
1.4 Field of study	Automation. Applied Informatics and Intelligent Systems
1.5 Cycle of study	Bachelor of Science
1.6 Program of study/Qualification	Automation and Applied Informatics (English)
1.7 Form of education	Full time

2. Data about the subject

2.1 Subject name	**Estimators in control of dynamic systems**			Discipline code	56.10
2.2 Course responsible/lecturer	*Prof.dr.ing. Zsofia Lendek, zsofia.lendek@aut.utcluj.ro*				
2.3 Teachers in charge of applications	*Prof.dr.ing. Zsofia Lendek, zsofia.lendek@aut.utcluj.ro*				
2.4 Year of study	4	2.5 Semester	2	2.6 Assessment *(E/C/V)*	C
2.7 Type of subject	*DF – fundamental, DS – specialty, DC – complementary*				DS
	DOB – compulsory, DOP – elective, DFA – optional				DOP

3. Estimated total time

3.1 Number of hours per week	3	of which:	Course	2	Seminar	0	Laboratory	1	Project 0
3.2 Number of hours per semester	42	of which:	course	28	Seminar	0	Laboratory	14	Project 0

3.3 Individual study	
(a) Manual, lecture material and notes, bibliography	10
(b) Supplementary study in the library, online and in the field	20
(c) Preparation for seminars/laboratory works, homework, reports, portfolios, essays	47
(d) Tutoring	3
(e) Exams and tests	3
(f) Other activities:	

3.4 Total hours of individual study (sum of (3.3(a)…3.3(f)))	83
3.5 Total hours per semester (3.2+3.4)	125
3.6 Number of credit points	5

4. Pre-requisites (where appropriate)

4.1 Curriculum	Numerical calculus, analysis, linear algebra, differential equations, control engineering
4.2 Competence	Numerical calculus, analysis, linear algebra, differential equations, control engineering

5. Requirements (where appropriate)

5.1. For the course	Attending at least 7 lectures is compulsory.
5.2. For the applications	Presence and successfully completing the project are compulsory

6. Specific competences

Professional competences	C1 Use of knowledge in mathematics, physics, measurement techniques, technical drawing, mechanical engineering, chemical engineering, electrical engineering, and electronics in systems engineering. C1.2 Explaining engineering problems to be solved and justifying solutions in systems engineering through the application of techniques, concepts, and principles from mathematics, physics, chemistry, technical drawing, electrical engineering, and electronics. C1.3 Solving common problems in the field of systems engineering by identifying appropriate techniques, principles, and methods, and by applying mathematics, with an emphasis on numerical computation methods. C3 Use of the fundamentals of automatic control, modeling, simulation, identification, and process analysis methods, as well as computer-aided design (CAD) techniques. C3.2 Explaining and interpreting automation problems for various types of processes by applying the fundamentals of automatic control, methods of modeling, identification, simulation, and process analysis, as well as computer-aided design (CAD) techniques.

Cross competences	

7. Expected learning outcomes

Knowledge	The student applies the fundamentals of automatic control and methods of process modeling, simulation, identification, and analysis to solve estimation and control problems specific to dynamic and industrial systems. They employ both conventional and artificial intelligence–based computer-aided design techniques to optimize the performance of automated and intelligent systems. Furthermore, the student develops and implements automatic control algorithms and control structures using modern programming environments, microcontrollers, embedded systems, and advanced information technologies. They are capable of formulating and solving optimization problems in applications involving automatic control, robotics, and intelligent control systems.
Skills	Applies evaluation criteria and methods to identify, model, experiment with, analyze, and qualitatively and quantitatively assess phenomena and processes specific to the field, including the use of digital technologies. Designs solutions to medium-complexity engineering problems while considering performance, safety, sustainability, and economic constraints. Applies modern project management techniques, economic methods, and decision-making approaches, including in multidisciplinary contexts. Applies engineering techniques, principles of physics, and appropriate mathematical methods to solve systems engineering problems, with an emphasis on estimation and control methods for linear systems. Selects and applies field-specific scientific methods and techniques in the development and implementation of systems engineering projects and analyzes the advantages and disadvantages of the proposed methods. Interprets and explains automation problems using systems theory, modeling and simulation, analytical methods, and computer-aided design techniques. Specifies requirements, develops simulation scenarios, proposes control solutions, and analyzes the performance of automated systems. Models, simulates, and experimentally analyzes processes using mathematical foundations. Designs and implements control systems based on both conventional algorithms and artificial intelligence techniques. Develops software solutions that integrate algorithm design, data management, and workflow automation for engineering applications.
Responsibilities and autonomy	Practices logical reasoning, evaluation, and self-assessment in decision-making processes. Communicates the results of engineering activities effectively to both technical and non-technical audiences. Demonstrates a commitment to lifelong learning and the continuous updating of professional knowledge. Works effectively in multidisciplinary teams and contributes constructively to the development of engineering solutions. Carries out project management processes and clearly presents results both verbally and in writing. Takes responsibility for the quality, safety, and ethical implications of the solutions developed. Uses engineering tools and platforms responsibly, following best practices for configuration, testing, and deployment. Plans, executes, and independently manages engineering tasks, from problem formulation to solution delivery, demonstrating initiative in adopting new methods and technologies.

8. Course objectives

General objective	Estimation problems in control engineering Design of commonly used observers
Specific objectives	Formulating an estimation problem Observability analysis Methods used for state estimation for a linear system

9. Contents

<table>
<tr><td>9.1 Lecture</td><td>No.hours</td><td>Teaching methods</td><td>Notes</td></tr>
<tr><td>Introduction. State-space description of dynamical systems. Formulating an estimation problem. Soft sensors. Case studies: electromechanical systems, 3D crane, inverted pendulum, robotic manipulators, quadcopters.</td><td>6</td><td rowspan="6">Exposition
Questions
Discussions with students
Proofs</td><td rowspan="6">Possibly online on Teams platform</td></tr>
<tr><td>Observers for linear systems. Luenberger observers in discrete and continuous time. Convergence of the estimated values to the real ones. Limitations. Case studies: experiments from the Rotary package (Quanser).</td><td>4</td></tr>
<tr><td>Linear regression. Least squares methods. The effect of noise. Case study: 3D crane.</td><td>2</td></tr>
<tr><td>Noises and disturbances. Kalman filters in continuous and discrete time. Analysis. Estimation with bounded inputs and states. Prediction and smoothing. Limitations. Case studies: sensor fusion for mobile robots.</td><td>6</td></tr>
<tr><td>Sensor and actuator faults. Fault detection. Case studies: electromechanical systems.</td><td>4</td></tr>
<tr><td>Observers design for control. The separation principle. Case studies: robotic systems.</td><td>6</td></tr>
<tr><td colspan="4">Bibliography:
1.Beyond the Kalman filter : particle filters for tracking applications, Branko Ristic, Sanjeev Arulampalam, Neil Gordon, Artech House, 2003
2.Modern control design : with MATLAB and SIMULINK, Ashish Tewari, Wiley, 2002
3.Stability analysis and nonlinear observer design using Takagi-Sugeno fuzzy models, Zsofia Lendek, Thierry Marie Guerra, Robert Babuska, Bart De Schutter, Springer, 2011
4.Optimal State Estimation: Kalman, H-infinity, and Nonlinear Approaches, Dan Simon, Wiley, 2006
5. Lecture notes available online at lendek.net/teaching</td></tr>
<tr><td>9.2 Aplications (seminar/laboratory/project/practical work)</td><td>No.hours</td><td>Teaching methods</td><td>Notes</td></tr>
<tr><td>State-space representation of linear systems. Examples. Variables and parameters that need to be estimated. Applications.</td><td>2</td><td rowspan="5">Implementation and analysis.

Literature study, implementing methods or applications, report writing</td><td rowspan="5">Attendance mandatory. Matlab will be used. Possibly online on Teams platform</td></tr>
<tr><td>Luenberger observers. Applications.</td><td>3</td></tr>
<tr><td>Linear regression. Applications.</td><td>2</td></tr>
<tr><td>Kalman filters in continuous and discrete time. Prediction and smoothing. Extended Kalman filters. Applications.</td><td>4</td></tr>
<tr><td>Sensor and actuator faults. Observer design for fault detection. Applications.</td><td>3</td></tr>
<tr><td colspan="4">Bibliography:
1.Beyond the Kalman filter : particle filters for tracking applications, Branko Ristic, Sanjeev Arulampalam, Neil Gordon, Artech House, 2003
2.Modern control design : with MATLAB and SIMULINK, Ashish Tewari, Wiley, 2002
3.Stability analysis and nonlinear observer design using Takagi-Sugeno fuzzy models, Zsofia Lendek, Thierry Marie Guerra, Robert Babuska, Bart De Schutter, Springer, 2011
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5. Lecture notes available online at lendek.net/teaching</td></tr>
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10. Bridging course contents with the expectations of the representatives of the community, professional associations and employers in the field

The alignment of the course content with the expectations of the epistemic community, professional associations, and representative employers in the field associated with the study program is achieved through the study of modern state and parameter estimation methods for dynamic systems, which are widely used in both academic research and current industrial applications.

Estimators play an essential role in many engineering applications, as, in practice, not all variables of interest can be measured directly. The course provides students with the theoretical and practical foundations required to identify situations where estimation is necessary, formulate and analyze estimation problems, select appropriate methods, and interpret the obtained results.

The competencies developed through this course address current needs in the fields of automatic control and systems engineering and are directly relevant to the design and implementation of modern control systems. The acquired knowledge can be applied both in industrial environments, in applications such as state-feedback control, process monitoring, system design, and performance optimization of automated systems, and in academic environments through research and development activities related to estimation and control of dynamic systems.

11. Evaluation

Activity type	**11.1 Assessment criteria**	**1.2 Assessment methods**	**11.3 Weight in the final grade**
11.4 Course	Level of understanding of the material	Colloquium	1
11.5seminar/laboratory/project/ practical work	Implementation, analysis, report, discussion	Validation during the semester	
11.6 Minimum performance standard: Attendance of at least 7 lectures, project successfully defended, and final grade >=5			

Date of filling in:		**Title Firstname NAME**	**Signature**
10.07.2026	Course	Prof.dr.ing. Zsofia Lendek	
	Aplications	Prof.dr.ing. Zsofia Lendek	

Date of approval by the Department Board	Head of Departament Prof.dr.ing. Honoriu VĂLEAN
Date of approval by the Faculty Council	Dean Prof.dr.ing. Vlad MUREȘAN