UNIVERSITATEA BABEŞ-BOLYAI
BABEŞ-BOLYAI TUDOMÁNYEGYETEM
BABEŞ-BOLYAI UNIVERSITÄT
BABEŞ-BOLYAI UNIVERSITY
TRADITIO ET EXCELLENTIA

Tradiție și Excelență prin
Cultură - Știință - Inovație din 1581

Facultatea de Chimie și Inginerie Chimică
Str. Arany János nr. 11
Cluj-Napoca, cod poștal 400028
Tel.: 0264-59.38.33
Fax: 0264-59.08.18

secretariat.chem@ubbcluj.ro
www.chem.ubbcluj.ro

SYLLABUS

Advanced Process Control (Automatizari si conducerea evoluata a proceselor)

University year 2025-2026

1. Information regarding the programme

1.1. Higher education institution	Babeș-Bolyai University of Cluj-Napoca
1.2. Faculty	Chemistry and Chemical Engineering
1.3. Department	Chemical Engineering
1.4. Field of study	Chemical Engineering
1.5. Study cycle	Master
1.6. Study programme/Qualification	Advanced Chemical Process Engineering
1.7. Form of education	Full-time education

2. Information regarding the discipline

2.1. Name of the discipline	**Automation and Advanced Process Control**					Discipline code	**CME7322**
2.2. Course coordinator	Prof. dr. ing. Cristea Vasile Mircea						
2.3. Seminar coordinator	Prof. dr. ing. Cristea Vasile Mircea						
2.4. Year of study	I	2.5. Semester	2	2.6. Type of evaluation	E	2.7. Discipline regime	FD/Compulsory

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	**2**
3.4. Total hours in the curriculum	56	of which: 3.5 course	28	3.6 ~~seminar~~/laborator	28
Time allotment for individual study (ID) and self-study activities (SA)					**hours**
Learning using manual, course support, bibliography, course notes (SA)					24
Additional documentation (in libraries, on electronic platforms, field documentation)					17
Preparation for seminars/labs, homework, papers, portfolios and essays					20
Tutorship (professional advice)					3
Evaluations					3
Other activities: (Communications with course/seminar/laboratolry coordinators)					2
3.7. Total individual study hours	**69**				
3.8. Total hours per semester	**125**				
3.9. Number of ECTS credits	**5**				

4. Prerequisites (if necessary)

4.1. curriculum	Basic Process Control.
4.2. competencies	Basic computer skills for Matlab.

5. Conditions (if necessary)

5.1. for the course	• Students must turn off their mobile phones during classes and seminars. • Students attending classes must be present for classes without delay.

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5.2. for the seminar /lab activities	• The seminar/laboratory grade is composed of the grade on homework, proactive participation in the laboratory and seminar, and the seminar/lab examinations. • The minimum grade that allows access to the exam is 5 • Absence from the laboratory, justified by documents (e.g. sick leave); seminar/lab activities where the student was absent may be made on the specific dates established by the course/laboratory holder • The deadline for submitting the homework results will be agreed upon by the seminar holder and the students. Delays in submitting the homework results will not be accepted unless there are proven good reasons (medical) • In the case of late submission of the homework, the grade will be penalized with 0.5 points/week of delay. • Students must be present at the (mandatory) seminars/laboratories without delay.

6. Specific competencies acquired [1]

Professional/essential competencies	• capacity of conceiving a control system dedicated to a specific process, capacity of conceiving and writing a mathematical model of high complexity dedicated to a certain specific process, capacity of choosing an appropriate control solution based on the analysis of the process model, economic analysis of efficiency of the chosen control solution, capacity of operating a complex plant.
Transversal competencies	• ability of systemic thinking, holistic thinking, critical thinking, argumentative, problem-solving orientation, high level of computer skills, analysis of a process based on a mathematical model.

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

7.1 General objective of the discipline	• Acquiring the knowledge necessary to understand the functioning, operation and design of advanced automatic control systems intended to perform the management of laboratory and industrial chemical processes. • Understanding the behavior of a complex chemical process, based on a mathematical model of that process and implementation of the automatic control diagram.
7.2 Specific objective of the discipline	• To develop control systems specific to chemical processes and fulfill their imposed control performance

8. Content

8.1 Course	Teaching methods	Remarks
8.1.1. **Cascade control. Feedforward control. Examples.** *Basic concepts, key words*: controllability, cascade,	Lecture Computer simulations	PowerPoint presentations, Matlab and Toolboxes for

[1] One can choose either competences or learning outcomes, or both. If only one option is chosen, the row related to the other option will be deleted, and the kept one will be numbered 6.

disturbance, parameters' tuning, energy consumption saving.	Power point presentations Interactive exercises	exemplification and applications.
8.1.2. **Feedforward control, Ratio control , Inferential control. Examples**. *Basic concepts, key words*: Feedforward, ratio, inferential control, economic justification.	Lecture Computer simulations Power point presentations Interactive exercises	PowerPoint presentations, Matlab and Toolboxes for exemplification and applications.
8.1.3. **Automatic control of the main process parameters. Examples**. *Basic concepts, key words*: temperature control, pressure control, level control, flow control, concentration control.	Lecture Computer simulations Power point presentations Interactive exercises	PowerPoint presentations, Matlab and Toolboxes for exemplification and applications.
8.1.4. **Chemical reactors' control. Types of reactors. Thermal instability of the reactors. Temperature control for the thermally unstable and stable reactors. Examples.** *Basic concepts, key words*: reaction kinetics, reaction rate, conversion, equilibria, enthalpy, thermal instability, Continuous Stirred Tank Reactor, Plug Flow Reactor, Mass Transfer Reactor, Electrochemical Reactor.	Lecture Computer simulations Power point presentations Interactive exercises	PowerPoint presentations, Matlab and Toolboxes for exemplification and applications.
8.1.5. **Chemical reactors' control.** *Basic concepts, key words*: steady state mathematical model, continuous /batch stirred tank reactors, plug flow reactors, mass transfer reactors, electrochemical reactors, microreactors, control design scheme.	Lecture Computer simulations Power point presentations Interactive exercises	PowerPoint presentations, Matlab and Toolboxes for exemplification and applications.
8.1.6. **pH control. Control of the distillation/rectification processes. Control of the distillation/rectification processes.** *Basic concepts, key words*: pH, instability. Economic considerations of the distillation processes, high value product recovery, material and energy balances, continuous/batch distillation.	Lecture Computer simulations Power point presentations Interactive exercises	PowerPoint presentations, Matlab and Toolboxes for exemplification and applications.
8.1.7. **Control of the distillation/rectification absorption/ desorption processes. Control of extraction processes.** *Basic concepts, key words*: : Material and energy balances, control schemes. Absorption/ desorption, mathematical model, exothermal processes, liquid- liquid extraction, solid-liquid extraction, separation interface.	Lecture Computer simulations Power point presentations Interactive exercises	PowerPoint presentations, Matlab and Toolboxes for exemplification and applications.
8.1.8. **Control of the drying process.** *Basic concepts, key words*: relative and absolute humidity, psychometric method, adiabatic drying.	Lecture Computer simulations Power point presentations Interactive exercises	PowerPoint presentations, Matlab and Toolboxes for exemplification and applications.
8.1.9. **Control of bioprocesses.** *Basic concepts, key words*: biochemical reactors, biomass, drying at low temperatures, mathematical model, sensitivity, control schemes.	Lecture Computer simulations Power point presentations Interactive exercises	PowerPoint presentations, Matlab and Toolboxes for exemplification and applications.
8.1.10. **Control of the thermally integrated processes.** *Basic concepts, key words*: controllability, instability, thermally integrated systems dynamics, economic analysis.	Lecture Computer simulations Power point presentations Interactive exercises	PowerPoint presentations, Matlab and Toolboxes for exemplification and applications.

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8.1.11. **Linear Model Predictive Control (MPC**); optimisation with constraints. MPC Tuning. *Basic concepts, key words*: models, objective function, constraints, linear programming, quadratic programming, explicit solution, weighting matrices.	Lecture Computer simulations Power point presentations Interactive exercises	PowerPoint presentations, Matlab and Toolboxes for exemplification and applications.
8.1.12. **Nonlinear Model Predictive Control (MPC**); optimisation with constraints, stability, adaptive MPC, hierarchical MPC, linearization. *Basic concepts, key words*: continuous/discrete models, linearization, sequential and simultaneous nonlinear programming methods, end-point (terrminal) terms (constraints).	Lecture Computer simulations Power point presentations Interactive exercises	PowerPoint presentations, Matlab and Toolboxes for exemplification and applications.
8.1.13. **Control systems implementing fuzzy-logic.** *Basic concepts, key words*: fuzzy sets, membership functions, fuzzy rules, fuzzification, inference, defuzzification, control.	Lecture Computer simulations Power point presentations Interactive exercises	PowerPoint presentations, Matlab and Toolboxes for exemplification and applications.
8.1.14. **Control systems based on Artificial Neural Networks (ANNs).** *Basic concepts, key words*: dynamic models built with ANNs, MPC using ANN models.	Lecture Computer simulations Power point presentations Interactive exercises	PowerPoint presentations, Matlab and Toolboxes for exemplification and applications.

Bibliography

1. Paul Șerban Agachi, Mircea Vasile Cristea, Alexandra Ana Csavdári, Botond Szilágyi, Advanced Process Engineering Control, De Gruyter Publishing House, Editura De Gruyter GmbH, Berlin, 2016,
2. Agachi P.S., Cristea M.V, Basic Process Engineering Control, Editura De Gruyter GmbH, Berlin, ISBN: 978-3-11-028981-7, e-ISBN: 978-3-11-028982-4, 360 p., 2014,
3. V. M. Cristea, S. P. Agachi, *Elemente de Teoria Sistemelor*, Editura Risoprint, Cluj-Napoca, 2002,
4. P.S. Agachi, Z.K. Nagy, M.V. Cristea, A. Imre-Lucaci – *Model Based Control, Case studies in process engineering*, Ed. Wiley-VCH, Weinheim, 2006.
5. V. M. Cristea PowerPoint presentations of the courses.

Supplementary Bibliography

6. F. Greg Shinskey - *Process Control Systems Application, Design and Tuning*, Ed. Mc.Graw Hill, New York, 1996,
7. Paul Serban Agachi – *Automatizarea Proceselor Chimice*, Ed. Casa Cărții de Știință, Cluj-Napoca, 1994,
8. P. Serfelis, M.C. Georgiadis, *The Integration of Process Design and Control*, Elsevier, 2004.

Note: titles can be accessed at the Library of the Department of Chemical Engineering of the Faculty of Chemistry and Chemical Engineering, at the Central University Library "Lucian Blaga" and at the Library of the Technical University of Cluj

8.2 Seminar / laboratory	Teaching methods	Remarks
8.2.1. **Cascade control. Design.** *Basic concepts, key words*: temperature cascade control, flow ratio control, parameters tuning.	Practical laboratory Seminar Interactive discussions	Student's obligations: course and bibliography (selective) study, solving the homework.
8.2.2. **Ratio control. Design.** *Basic concepts, key words*: temperature cascade control, flow ratio control, parameters tuning.	Practical laboratory Seminar Interactive discussions	Student's obligations: course and bibliography (selective) study, solving the homework.
8.2.3. **Feed forward of a CSTR**. **Design.** *Basic concepts, key words*: disturbance, disturbance transducer, disturbance controller, stability.	Practical laboratory Seminar Interactive discussions	Student's obligations: course and bibliography (selective) study, solving the homework.

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8.2.4. **Feedback and feedforward of a CSTR. Design.** *Basic concepts, key words*: disturbance, disturbance transducer, disturbance controller, stability.	Practical laboratory Seminar Interactive discussions	Student's obligations: course and bibliography (selective) study, solving the homework.
8.2.5. **Feedforward control of a distillation column. Control of a binary distillation column.** *Basic concepts, key words*: heat transfer, mass transfer, impulse transfer, feed disturbance, stability.	Practical laboratory Seminar Interactive discussions	Student's obligations: course and bibliography (selective) study, solving the homework.
8.2.6. **Control of the bio-reactor.** *Basic concepts, key words*: bioreactor, mass of reaction, bio-mass, reaction kinetics, analysers, control structures.	Practical laboratory Seminar Interactive discussions	Student's obligations: course and bibliography (selective) study, solving the homework.
8.2.7. **Control of the Waste Water Treatment Plant WWTP (I).** *Basic concepts, key words*: modelling nitrification and denitrification bioreactors, bioreaction kinetics, control structures.	Practical laboratory Seminar Interactive discussions	Student's obligations: course and bibliography (selective) study, solving the homework.
8.2.8. **Control of the Waste Water Treatment Plant WWTP (II).** *Basic concepts, key words*: control of the settler (secondary and primary), aeration control strategies, control for minimizing energy costs and maximizing effluent quality.	Practical laboratory Seminar Interactive discussions	Student's obligations: course and bibliography (selective) study, solving the homework.
8.2.9. **Developing application for MPC with and without constraints,** using both CETM and command prompt. Simulink implementation. Tuning SISO and MIMO MPC. *Basic concepts, key words*: nonlinear process, Simulink MPC block, tuning, stability, command prompt developed MPC.	Practical laboratory Seminar Interactive discussions	Student's obligations: course and bibliography (selective) study, solving the homework.
8.2.10. **MPC Control of the Fluid Catalytic Cracking Unit (I)** *Basic concepts, key words*: heat transfer, mass transfer, impulse transfer, feed disturbance, stability.	Practical laboratory Seminar Interactive discussions	Student's obligations: course and bibliography (selective) study, solving the homework.
8.2.11. **MPC Control of the Fluid Catalytic Cracking Unit (II)** *Basic concepts, key words*: Control of the riser, stripping vessel, regenerator, air blower, wet-gas compressor, main fractionator.	Practical laboratory Seminar Interactive discussions	Student's obligations: course and bibliography (selective) study, solving the homework.
8.2.12. **Application and implementation demonstration of a Fuzzy Controller, using Fuzzy Logic Toolbox.** *Basic concepts, key words*: fuzzy sets, membership functions, fuzzy rules, fuzzification, inference, defuzzification, control.	Practical laboratory Seminar Interactive discussions	Student's obligations: course and bibliography (selective) study, solving the homework.
8.2.13. **Application and implementation demonstration of MPC using ANN models (I).** *Basic concepts, key words*: training, dynamic ANN, nonlinear model.	Practical laboratory Seminar Interactive discussions	Student's obligations: course and bibliography (selective) study, solving the homework.
8.2.14. **Application and implementation demonstration of MPC using ANN models (II).** *Basic concepts, key words*: FCCU application, drying electric insulators.	Practical laboratory Seminar Interactive discussions	Student's obligations: course and bibliography (selective) study, solving the homework.

Bibliography

1. Paul Şerban Agachi, Mircea Vasile Cristea, Alexandra Ana Csavdári, Botond Szilágyi, Advanced Process Engineering Control, De Gruyter Publishing House, Editura De Gruyter GmbH, Berlin, 2016,
2. G. Stephanopoulos, Chemical Process Control An Introduction to Theory and Practice, Prentice Hall, 1984,

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3. Mihaela Iancu, P.Ş.Agachi, M.Mogoş, M.Cristea, Automatizarea Proceselor Chimice – Lucrări de Laborator, Presa Universitară Clujeană, UBB, 2012.

Supplementary Bibliography
4. *Control System Toolbox,* Matlab, Documentation accompanying toolbox,
5. *Model Predictive Control Toolbox,* Matlab, Documentation accompanying toolbox,
6. *Fuzzy Logic Toolbox,* Matlab, Documentation accompanying toolbox,

Paul Serban Agachi – Automatizarea Proceselor Chimice, Ed. Casa Cărţii de Ştiinţă, 1994.

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

- Curriculum was elaborated after consultancy with the PC groups from the universities in Iasi, Bucuresti, Ploieşti, Constanta and Timişoara
- Process Engineering was introduced based on a WB program of Computer Aided Process Engineering (1998-2002)
  Feedback from the industry (Azomures, Emerson, Rompetrol; St. Gobain Rigips) has been used to comply with the expected competencies desired by potential employers.
- The competencies and qualifications have been set in accordance to the Diploma Supplement and qualifications of the National Authority of Qualifications standards

10. Evaluation

Activity type	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Percentage of final grade
10.4 Course	Understanding of the processes discussed Specificity of the answers Holistic thinking and approach	On-site or online examination method. The examination consists in the elaboration of a paper in which answers will be given to the subjects (questions / problems) from the course topic. Access to the exam is conditioned by the presentation of the solutions to the received homeworks. Fraud intention at the exam is punishable by removal from the exam. Fraud of the examination is punishable by removal from the examination and by expulsion according to the ECB regulations of the UBB.	75
	Understanding of the discussed processes. Specificity of the answers. Holistic thinking and approach.	On-site or online evaluation. The solved homeworks are presented at the next seminar meeting. Examination during the seminar.	10
	Ability to use different sources of information.		5
	Quality of solved homework / tests.		10
10.6 Minimum standard of performance			

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- Obtaining a minimum grade of 5 (five) both in the evaluations related to the course, seminar, solving the received homeworks.
- Obtaining the minimum grade 5 (five) both in the evaluation of the theoretical part and the problem part, in the examination.

11. Labels ODD (Sustainable Development Goals)[2]

Date:
31.03. 2025

Signature of course coordinator
Cristea V. M.

Signature of seminar coordinator
Cristea V. M.

Date of approval:
14.04.2025

Signature of the head of department
Prof. dr. eng. Graziella Liana Turdean

[2] Keep only the labels that, according to the *Procedure for applying ODD labels in the academic process*, suit the discipline and delete the others, including the general one for *Sustainable Development* – if not applicable. If no label describes the discipline, delete them all and write „*Not applicable*.".