COURSE DESCRIPTION

Automation and Evolved Management of Chemical Processes

Academic year 2026 - 2027

1. Programme-related data

1.1. Higher Education Institution	Babeş-Bolyai University of Cluj-Napoca
1.2. Faculty	Chemistry and Chemical Engineering
1.3. Department	Chemical Engineering
1.4. Field	Chemical Engineering
1.5. Level of study	Master
1.6. Degree programme / Qualification	Chemistry and Engineering of Nano- and Biomaterials
1.7. Form of education	Full-time education

2. Course-related data

2.1. Course title	**Automation and Evolved Management of Chemical Processes**				Course code	**CME7325**
2.2. Course coordinator	Vacant position					
2.3. Seminar coordinator	Vacant position					
2.4. Year of study	1	2.5. Semester	2	2.6. Type of assessment	Exam	
2.7. Course status	Optional			2.8. Course type	Specialisation subject	

3. Total estimated time (hours per semester of teaching activities)

3.1. Number of hours per week	**4**	of which: 3.2. course	**2**	3.3. seminar/ laboratory/ project	**2**
3.4. Total of hours in the curriculum	56	of which: 3.5. course	28	3.6. seminar/ laboratory	**28**
Time allocation for individual study (IS) and self-taught activities (ST)					**hours**
Learning from textbooks, course materials, bibliography, and notes (IS)					24
Additional research in the library, on subject-specific electronic platforms, and on-site					17
Preparing seminars/ laboratories/ projects, assignments, reports, portfolios, and essays					16
Tutoring (professional guidance)					7
Examinations					3
Other activities					2
3.7. Total hours of individual study (IS) and self-taught activities (ST)			**69**		
3.8. Total hours per semester			**125**		
3.9. Number of credits			**5**		

4. Prerequisites (where applicable)

4.1. curriculum-related	Basic Process Control
4.2 skills-related	Basic computer skills for Matlab

5. Specific conditions (where applicable)

5.1. course-related	• Students attending classes have to be present for classes without delay. • Students must turn off their communication devices (mobile phones, etc.) during classes and seminars.
5.2. seminar/laboratory-related	• 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 up 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 (e.g. 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 (mandatory) at the seminars/laboratories without delay.	

6.1. Competencies resulting from the completion of the degree programme *(as referred to in the curriculum)*[1]

Professional competencies	
Competency code	**Competency**
CP2	The ability to design experiments and processes for preparation of nano- and biomaterials using computer-aided tools and taking into account sustainable development aspects.
CP3	Development and use of mathematical models and simulators in nano- and biomaterials process engineering, for the optimization and management of nanotechnological processes.
CP4	kills in developing technical, economic and environmental impact analyses for chemical processes and the production of new bio- and nanomaterials.
Transversal competencies	
Competency code	**Competency**
TC1	Ability to work autonomously to develop, program and implement on one's own initiative the actions in the developed research plans.
TC2	Ability to lead or participate in international research teams within research projects or to transfer research results to industry or society.

6.2. Learning outcomes relevant to the degree programme (as referred to in the curriculum)[2]

Learning outcomes targeted by the subject		
Competency code	**Knowledge and comprehension**	**Specific academic skills**
PC2, TC1	1. Development of technologies for obtaining bio- and nanomaterials, based on CAD tools, as well as their characterization.	1. Development of integrated projects, based on CAD tools, for the creative development of the tehnologies for bio- and nanomaterials.
PC5, TC2	2. Knowledge of concepts and theories specific to resources and quality management for bio- and nanotehnologies, in the context of sustainable development	2. Use of qualitative and quantitative methods for assessing risk factors, operational safety and management, in the development of new projects for resources and quality management.

7. Subject-specific learning outcomes

Knowledge and comprehension
1. Conceiving of a control system dedicated to a specific process for obtaining bio- and nanomaterials.

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[1] The professional and/or transversal skills targeted by the subject for which the course description is prepared will be copied from the curriculum of the degree programme. For each competency, the complete entry, including the competency code, will be copied with the exact wording that appears in the curriculum, without any changes. If no competency is copied from either of the two categories, the row corresponding to that category is deleted from the table.

[2] The learning outcomes relevant for the degree programme and targeted by the subject for which the course description is prepared will be listed. The entries, copied without any changes from the Curriculum by subject type (Core Subject/Specialisation Subject/Complementary Subject), are listed under the corresponding competency.

2. Conceiving and elaborating a mathematical model of high complexity dedicated to a certain specific process for obtaining bio- and nanomaterials, to be further used for process control.
3. Designing an appropriate control solution based on the analysis of the process model for obtaining bio- and nanomaterials, efficiency, economic analysis, sustainability and performance assessment of the chosen control solution.
4. Operating a complex plant based on the designed control solution.
Specific academic skills
1. Ability of systemic thinking, holistic thinking and critical thinking for the chemical process design.
2. Argumentative, problem-solving orientation ability, with application to the process control.
3. High level of computer skills and ability of analysing a process behaviour based on its mathematical model.

8. Contents

8.1. Course	**Teaching and learning methods**	**Remarks[3]**
8.1.1. **Cascade control. Feedforward control. Examples.** *Basic concepts, key words*: controllability, cascade, disturbance, parameters' tuning, energy consumption saving.	Lecture Computer simulations Power point presentations Interactive exercises	PowerPoint presentations, Matlab and Toolboxes for 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	Lecture Computer simulations Power point presentations Interactive exercises	PowerPoint presentations, Matlab and Toolboxes for exemplification and applications.

[3] For example, organisational aspects, recommendations for students, specific aspects relating to the course/seminar, such as inviting experts in the field, etc.

model, exothermal processes, liquid- liquid extraction, solid-liquid extraction, separation interface.		
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.
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 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. 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. 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 Cărţii de Stiinţă, 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 and learning 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.
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 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. G. Stephanopoulos, Chemical Process Control An Introduction to Theory and Practice, Prentice Hall, 1984,
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,
7. Paul Serban Agachi – Automatizarea Proceselor Chimice, Ed. Casa Cărţii de Ştiinţă, 1994

9. Evaluation

Type of activity	9.1 Evaluation criteria[4]	9.2 Evaluation methods[5]	9.3 Percentage in the final grade
9.4 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
9.5. Seminar/ laboratory	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
9.6 Minimum standard for passing			

- 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.

[4] The evaluation criteria must directly reflect the learning outcomes targeted at the level of the degree programme respectively at the level of the subject. More specifically, the learning outcomes set out in the expected learning outcomes are assessed.

[5] Both final evaluation methods and ongoing evaluation strategies should be established.

10. SDG labels (Sustainable Development Goals)[6]

	○	Eticheta generală pentru Dezvoltare durabilă						
1 FĂRĂ SĂRĂCIE	2 FOAMETE „ZERO”	3 SĂNĂTATE ȘI BUNĂSTARE	4 EDUCAȚIE DE CALITATE	5 EGALITATE DE GEN	6 APĂ CURATĂ ȘI SANITAȚIE	7 ENERGIE CURATĂ ȘI LA PREȚURI ACCESIBILE	8 MUNCĂ DECENTĂ ȘI CREȘTERE ECONOMICĂ	9 INDUSTRIE, INOVAȚIE ȘI INFRASTRUCTURĂ
○	○	○	○	○	○	○	○	◉
10 INEGALITĂȚI REDUSE	11 ORAȘE ȘI COMUNITĂȚI DURABILE	12 CONSUM ȘI PRODUCȚIE RESPONSABILE	13 ACȚIUNE CLIMATICĂ	14 VIAȚA ACVATICĂ	15 VIAȚA TERESTRĂ	16 PACE, JUSTIȚIE ȘI INSTITUȚII EFICIENTE	17 PARTENERIATE PENTRU REALIZAREA OBIECTIVELOR	Nu se aplică nici o etichetă
○	○	○	○	○	○	○	○	○

Date of entry: 29.04.2026	Signature of course coordinator vacant	Signature of seminar coordinator vacant

Date of approval in the department: 30.04.2026	Signature of the head of department

[6] Select a single label which, according to the *Implementation of SDG labels in the academic process*, best matches the subject. If the subject addresses sustainable development in a generic manner (i.e. by presenting/introducing the general framework of sustainable development, etc.), then the Sustainable Development generic label may be applied. If none of the labels describe the subject, select the last option: *"No label applies."*