SYLLABUS

1. Information regarding the programme

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 of study	Chemical Engineering
1.5 Study cycle	Master
1.6 Study programme / Qualification	Advanced Chemical Process Engineering

2. Information regarding the discipline

2.1 Name of the discipline	**Advanced Process Control – CME7322**						
2.2 Course coordinator	Vacant position (Prof.dr.ing.Cristea Vasile Mircea)						
2.3 Seminar coordinator	Vacant position						
2.4. Year of study	I	2.5 Semester	2	2.6. Type of evaluation	WE	2.7 Type of discipline	Compulsory

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

3.1 Hours per week	3	Of which: 3.2 course	2	3.3 seminar/laboratory	1
3.4 Total hours in the curriculum	42	Of which: 3.5 course	28	3.6 seminar/laboratory	14
Time allotment:					hours
Learning using manual, course support, bibliography, course notes					40
Additional documentation (in libraries, on electronic platforms, field documentation)					28
Preparation for seminars/labs, homework, papers, portfolios and essays					28
Tutorship					3
Evaluations					3
Other activities:					6

3.7 Total individual study hours	108
3.8 Total hours per semester	150
3.9 Number of ECTS credits	6

4. Prerequisites (if necessary)

4.1. curriculum	• Basic Process control, Basic Chemical Engineering
4.2. competencies	• engineering

5. Conditions (if necessary)

5.1. for the course	• Presence at classes is part of the final notation
5.2. for the seminar /lab activities	• Minimum average allowed for entering the examination is 5 • All lab hours and seminar are compulsory

6. Specific competencies acquired

Professional 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 a 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	• To make the student understand the behaviour of a complex process based on a mathematical model and to implement a control scheme
7.2 Specific objective of the discipline	• To develop a control system adequate to a specific process

8. Content

8.1 Course	Teaching methods	Remarks
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	Lecture Computer simulations Power point presentations Interactive exercises	PowerPoint presentations, Matlab and Toolboxes for exemplification and

reactors, mass transfer reactors, electrochemical reactors, microreactors, control design scheme.		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.
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

. P..S. Agachi, V.M. Cristea, Basic Process Engineering Control, Editura De Gruyter GmbH, Berlin, 2014.
2. Paul Serban Agachi – *Automatizarea Proceselor Chimice*, Ed. Casa Cărții de Stiință, Cluj-Napoca, 1994.
3. 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.
4. F. Greg Shinskey - *Process Control Systems Application, Design and Tuning*, Ed. Mc.Graw Hill, New York, 1996.
5. William Luyben – *Plantwide dynamic simulators in chemical processing and control*, Ed. Marcel Dekker Inc., Basel, 2002.
6. V. Mircea Cristea, P. Serban Agachi, *Elemente de Teoria Sistemelor*, Ed. Risoprint, Cluj-Napoca, 2002.
7. Gregory McMillan, Douglas Considine - *Process/ Industrial Instruments and Controls Handbook*, 5th Edition, Ed. Mc.Graw Hill, New York, 2000.
8. Stanley I. Sandler – *Chemical Engineering Thermodynamics*, Ed. John Wiley & Sons, 1998.
9. I Bâldea – *Cinetică chimică şi mecanisme de reacție. Baze teoretice şi aplicații*, Presa Universitară Clujeană, Cluj-Napoca, 2002.
10. S.Agachi, M.Cristea, *Automatizarea proceselor chimice. Caiet de lucrari practice*, Universitatea "Babes-Bolyai" Cluj, 1996.
11. F. Greg Shinskey – *Distillation control for productivity and energy conservation*, McGraw-Hill Book Company, 1984
12. Kai Sundmacher, A. Kienle, A.Seidel-Morgenstern, *Integrated Chemical Processes- Synthesis, Operation, Analysis and Control*, Wiley-VCH, 2005.
13. Steven H. Strogatz, *Nonlinear Dynamics and Chaos –With Applications to Physics, Biology, Chemistry and Engineering*, Perseus Books, 1994.
14. P. Serfelis, M.C. Georgiadis, *The Integration of Process Design and Control*, Elsevier, 2004.
15. Mustafa Özilgen, *Food Process Modeling and Control-Chemica Engineering Applications*, Gordon and Breach Science Publishers, 1998.
16. J. Ingham, I.J. Dunn, E. Heinzle, J.E. Prenosil, J. B. Snape, *Chemical Engineering Dynamics*, Wiley-VCH, 2007.
17. P.S. Agachi – Process dynamics and Control, EOLSS UNESCO Encyclopaedia, Chapter Chemical Engineering, 2011.

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 and ratio control.** *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. **Feed forward of a CSTR**. *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.
8.2.3. **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.
8.2.4**. Control of the bio-reactor.** *Basic concepts, key words*: bioreactor, mass of reaction,	Practical laboratory Seminar Interactive discussions	Student's obligations: course and bibliography (selective) study, solving

bio-mass, reaction kinetics, analysers, control structures.		the homework.
8.2.5. **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.
8.2.6. **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.
8.2.7. **Application and implementation demonstration of MPC using ANN models.** *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.

Bibliography

1. S.Agachi, M.Cristea, Automatizarea proceselor chimice. Caiet de lucrari practice, Universitatea "Babes-Bolyai" Cluj, 1996
2. Paul Serban Agachi – Automatizarea Proceselor Chimice, Ed. Casa Cărţii de Ştiinţă, 1994
3.G. Stephanopoulos, Chemical Process Control An Introduction to Theory and Practice, Prentice Hall, 1984.
4. Mihaela Iancu, P.Ş.Agachi, M.Mogoş, M.Cristea, Automatizarea Proceselor Chimice – Lucrări de Laborator, Presa Universitară Clujeană, UBB, 2012.
5. *Control System Toolbox,* Matlab, Documentation accompanying toolbox.
6. *Model Predictive Control Toolbox,* Matlab, Documentation accompanying toolbox.
7. *Fuzzy Logic Toolbox,* Matlab, Documentation accompanying toolbox.

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, Ploiesti and Timisoara
- Process Engineering was introduced based on a WB program of Computer Aided Process Engineering (1998-2002)

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Share in the grade (%)
10.4 Course	Understanding of the processes discussed Specificity of the answers Holistic thinking and approach	Open source written examination	40
	Capacity of using different	Open source written	10

	sources of information	examination	
10.5 Seminar/lab activities	Understanding of the processes discussed Specificity of the answers Holistic thinking and approach	Practical examination at the site	40
	Capacity of using different sources of information	Practical examination at the site	10
10.6 Minimum performance standards			
➢ 5 is the minimum average accepted for both types of examination			

Date — Signature of course coordinator — Signature of seminar coordinator

22.04. 2016

Date of approval — Signature of the head of the department