SYLLABUS

1. Information regarding the programme

1.1 Higher education institution	University Babeş-Bolyai, 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	Membrane processes - **CME7346**						
2.2 Course coordinator	Conf. dr. eng. Adrian Nicoara						
2.3 Seminar coordinator	Conf. dr. ing. Adrian Nicoara						
2.4. Year of study	**II**	2.5 Semester	**3**	2.6. Type of evaluation	**C**	2.7 Type of discipline	**Opt**

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+1
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					20
Additional documentation (in libraries, on electronic platforms, field documentation)					18
Preparation for seminars/labs, homework, papers, portfolios and essays					14
Tutorship					14
Evaluations					3
Other activities:					

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	• not necessary
4.2. competencies	• not necessary

5. Conditions (if necessary)

5.1. for the course	• The students attending this course will have the phones turned off. • Punctuality is requested.
5.2. for the seminar /lab activities	• The studenst must turn off the phones as long as they are in the laboratort. • They are requested to bring laboratory coats, gloves and lab cloth. • Under any circumstances, they are not allowed to leave a running experiment unsupervised. • The Laboratory reports will be done no later than the week following the effective conduct of the work.

	• It is forbidden to eat in the laboratory.

6. Specific competencies acquired

Professional competencies	Defining notions, concepts, theories and models in chemistry and depth chemical engineering process and their use in describing membrane processes. Using thorough knowledge of chemistry and chemical engineering process for explanation and interpretation of membrane processes. Critical analysis and use of principles, methods and techniques aiming advanced quantitative and qualitative evaluation of membrane processes.
Transversal competencies	Professional tasks accomplished according to specified requirements and deadlines imposed, in compliance with professional ethics and moral conduct, following a predetermined work plan and qualified guidance. Solving professional duties in accordance with the general objectives established by integrating the working group and task distribution for subordinate levels. Information and documentation in its ongoing activity in a foreign language with the use of modern information and communication

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

7.1 General objective of the discipline	• The course aims at knowing the main membrane processes and industrial applications of membranes used (structure, materials, production, properties). A strong emphasis is placed on practical applications in the current industry and modelling of separation
7.2 Specific objective of the discipline	• Acquiring knowledge about the structure and performance of various membranes widely used in industrial applications. Emphasis will be placed on conducting structure-type correlations obtained performance and modelling capabilities for creating membrane separation processes. In addition, graduates will be able to choose the correct type of membrane processes according to the desired requirements.

8. Content

8.1 Course	Teaching methods	Remarks
8.1.1. Introduction. Definition and classification of types of membranes and membrane processes. Driving forces and mass flows.	Lecture, explanation, conversation, description, PowerPoint presentations.	
8.1.2. Thermodynamic foundations of membrane separation. Elements of thermodynamics of irreversible processes. Phenomenological flows. Liquid junction, Donnan and membrane potentials.		
8.1.3. Membrane transport theory. The diffusion in dense medium. Structure-permeability correlation. The diffusion in porous media.		
8.1.4. Concentration polarization. The limit film model.. Experimental determination of Peclet criterion. Particulars of concentration polarization in gaseous and liquid environments. Cross-flow, co-flow contra-fluxes.		
8.1.5. Description of membranes and membrane modules: structure, preparation, performance. Isotropic and anisotropic membranes. Metallic and ceramic membranes. Liquid membranes.		
8.1.6. Membranes and membrane modules: structure,		

preparation, performance. Hollow fibre membranes. Membrane modules. Chemical modification of membranes.		
8.1.7. Reverse osmosis. Membranes and materials. Selectivity process. Control of membrane clogging. Methods for cleaning up. Applications.		
8.1.8. Ultra- and microfiltration. Membranes used. Concentration polarization. Clogging and cleaning. Membrane modules. Design. Applications.		
8.1.9. Separation from gaseous phase. Theoretical foundation. Membrane materials. Design. Applications.		
8.1.10. Pervaporation. Theoretical foundation. Membrane materials. Modules. Design. Applications.		
8.1.11. Membrane separation processes using ion exchange. Theoretical foundation. Chemistry of ion exchange membranes. Dialysis: variants (Donnan dialysis, dialysis speakers). Design, membranes, applications.		
8.1.12. Membrane separation processes ion exchange (continued). Mass transport by migration. Electrodialysis: design, skins and applications. Mosaic membranes. Piezodialysis; design applications. Membrane contactors and membrane distillation.		
8.1.13. Intensification of membrane transport. Transport against the gradient of chemical potential. Transporters. Coupled transport and facilitated. Applications.		
8.1.14. Membrane reactors. Theoretical basis. Requirements, applications.		
Bibliography 1. R. W. Baker. Membrane technology and applications, John Wiley & Sons,Chichester, 2004. 2. S. P. Nunes, K.-V. Peinemann, Membrane Technology in the Chemical Industry, Wiley-VCH, Weinheim, 2001. 3. J. Koryta, J. Dvorak şi L. Kavan, Principles of Electrochemistry, John Wiley & Sons, Chichester, 1993.		
8.2 Seminar / laboratory	Teaching methods	Remarks
Lab. 1. Determination of mass transport through membranes parameters.	Experiment, explanation, conversation, description, conceptualisation.	Laboratory activities will be structurated as one introductory session (2h) and three laboratory sessions (4h).
Lab. 2. Evaluation of ion-exchange membranes selectivity by electrochemical methods.		
Lab. 3. Dialysis separation of electrolytes.		
Sem. 1. Thermodynamics of irreversible processes. Flux and conservation equations.		
Sem. 2. Donnan and membrane potentials.		
Sem. 3. Mass transport across membranes.		
Sem. 4. Mass balance for dialysis reactors.		
Sem. 5. Mass and electrical charge balance equations in electrodyalisis reactors.		
Sem. 6. Energy balances in membrane reactors.		
Sem. 7. Optimisation of membrane processes.		
Bibliography 1. Lecture support. 2. Laboratory workbook.		

3. E.J. Hoffman, Industrial membrane separation technology. Elsevier, Amsterdam, 2003.

Optional bibliography

1. C. Liteanu, G. Rădulescu, Bazele membranologiei, Ed. Stiinţifică şi Enciclopedică, Bucureşti, 1984.

2. H.P. Hsieh, Inorganic Membranes for Separation and Reaction, Elsevier, Amsterdam, 1996.

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

- By learning the theoretical concepts and methodological approaches, students acquire practical aspects of membrane processes included in the discipline, a body of knowledge consistent with partial competencies required for possible occupations provided in Grid 1 - NQRHE.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Share in the grade (%)
10.4 Course	Correctness of the answers - learning and understanding of issues addressed in the course. Correctly solve of the problems.	Written examination - examination is conditioned by compliance laboratory works and submission of reports. Intention to fraud on examination is punishable by elimination from the exam. Examination fraud is punishable by expulsion as ECST regulation of UBB.	80%
10.5 Seminar/lab activities	Seminar / lab Fairness answers - learning and understanding of issues addressed in the seminar / laboratory	Papers covering all laboratory practical work are to be delivered until the last week of teaching activity.	20%
	Quality of prepared reports. Activity in laboratory.		
10.6 Minimum performance standards			

- Mark 5 (five) on both laboratory exam, and the exam according to the scale.
- Introduction knowledge, correct identification of transfer phenomena and type of membrane process. Correct identification of mass flows. Knowledge of the process quality parameters.

Date	Signature of course coordinator	Signature of seminar coordinator
.... 23.02.2018....	Conf.Dr.Eng. Adrian NICOARĂ	Conf.Dr.Eng. Adrian NICOARĂ

Date of approval

Signature of the head of department

Conf. Dr. Ing. Graziella Liana Turdean

February 26th, 2018