# Course guide
# 295559 - 295EQ121 - Membrane Processes and Technologies

**Last modified:** 14/06/2023

**Unit in charge:** Barcelona East School of Engineering
**Teaching unit:** 713 - EQ - Department of Chemical Engineering.

**Degree:** MASTER'S DEGREE IN CHEMICAL ENGINEERING (Syllabus 2019). (Optional subject).

**Academic year:** 2023 **ECTS Credits:** 6.0 **Languages:** English

## LECTURER

**Coordinating lecturer:** Cortina Pallas, Jose Luis

**Others:**

## PRIOR SKILLS

No aplica

## REQUIREMENTS

No aplica

## DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

**Generical:**
CGMUEQ-01. Ability to apply the scientific method and the principles of engineering and economics, to formulate and solve complex problems in processes, equipment, facilities and services, in which the matter undergoes changes in its composition, state or energy content, characteristic of the chemical industry and other related sectors among which are the pharmaceutical, biotechnological, materials, energy, food or environmental
CGMUEQ-04. To carry out the appropriate research, undertake the design and manage the development of engineering solutions, in new or little known environments, relating creativity, originality, innovation and technology transfer
CGMUEQ-08. Lead and define multidisciplinary teams capable of solving technical changes and management needs in national and international contexts

**Transversal:**
05 TEQ. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.
03 TLG. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.

## TEACHING METHODOLOGY

The following activities will be carried out, either in or outside the classroom, in the development of the course:

1. Lectures, participative sessions and problem solving sessions
2. Lectures by quest speakers
3. Autonomous learning and homework and assignments
4. Project based learning
5. Mid-term exam (MEX) and final Exam (FEX)
6. Visit to plants

Detailed project information regarding the scope, content, format, deadlines, etc., will be presented in an attached document.

The methodology designed includes also the Project based learning (PBL) where the students would have two types of projects: a) use commercial membrane design and projection tools to provide a design of a membrane based process; b) integration of membrane technologies on processing schemes of given priority sectors (chemical, pharmaceutical, agro-food, beverage, water/energy). Invited speakers are experts who work on membrane processing can participate in the definition of the system and supervising the progress of the teams.

## LEARNING OBJECTIVES OF THE SUBJECT

At the end of the course the student will be able to:
• Capacity to define separation, purification and concentration of solutes from streams in down-processing on chemical, biochemical, petrochemical processes based on the use of membrane materials and technologies.
• Know the operating principles of the different types of separation processes based on membranes in order to design their integration in chemical, pharmaceutical and food processes.
• To know the design tools of membrane separation processes using commercial calculation tools developed by the membrane suppliers as well as of equilibrium codes between phases to simulate and predict the operation of processes based on membranes.
• To know the methodologies of technological pre-evaluation, membrane characterization, study techniques and monitoring of the operation processes of the membranes in industrial processes.

## STUDY LOAD

| Type | Hours | Percentage |
|---|---|---|
| Hours large group | 28,0 | 18.67 |
| Hours small group | 14,0 | 9.33 |
| Guided activities | 6,0 | 4.00 |
| Self study | 102,0 | 68.00 |

**Total learning time:** 150 h

## CONTENTS

### 1. Membrane Technology Fundamentals

**Description:**
cOverview of membrane science and Technology: historical Development of membranes, types of membranes and membrane Processes. Membranes classification and types, membranes modules and configurations. Membrane transport theory: solution-diffusion model, structure–permeability relationships in Solution-diffusion. Membranes, Pore-flow Membranes. Concentration polarization: boundary Layer Film Mode. Polarization in Liquid Separation and Gas Separation Processes: cross-flow, co-flow and counter-flow operation modes

**Specific objectives:**
The student will develop a basic understanding of the main transport mechanisms and the flux equations of solvent and solutes in membrane processes. Sound knowledge on the main mass transport models will be derived from a thermodynamic approach. Finally, the main process limitations on mass transfer as concentration processes will be evaluated and the main module configuration and operation approaches to diminish them will be presented. The student will learn the main operation modes and membranes configurations.

**Related activities:**
Homework assignment: Short exercises
Visualization of videos on membrane preparation and modules construction.

**Full-or-part-time:** 24h
Theory classes: 7h
Guided activities: 2h
Self study : 15h

### 2. Pressure driven porous membrane processes

**Description:**
Microfiltration: Membrane properties. Membrane flux derivation and fouling indexes. Cleaning processes. Membranes and Modules. System Design. Applications
Ultrafiltration: Characterization of UF membranes and molecular cut-off. Concentration Polarization and Membrane Fouling. Membrane Cleaning. Membranes and Modules. System Design. Applications
content english

**Specific objectives:**
Distinguish the conditions and requirements of the application of porous membranes: particulate and colloidal matter removal. The main tools for controlling production modes and cleaning modes including numerical tools and operation tools. The identification of the lower limit of application of UF, and their role for clean-up/separation of macromolecules would be solidified. Finally, a familiarization with software for defining porous filtration stage will be completed.

**Related activities:**
Homework assignment: Short exercises
Project on developing a projection for a process using UF using a commercial design tool.

**Full-or-part-time:** 27h
Theory classes: 7h
Guided activities: 4h
Self study : 16h

### 3. Pressure driven non-porous membranes

**Description:**
Reverse osmosis (RO) and Nano-filtration(NF). Theoretical background. Membranes and Materials. Reverse Osmosis and Nano-filtration membrane categories. Membrane Selectivity. Membrane Modules. Membrane Fouling Control and Cleaning. Applications. Gas Separation Processes. Theoretical Background. Membrane Materials and Structure. Membrane Modules. Process Design and applications.
Pervaporation Separation Processes. Theoretical Background. Membrane Materials and Structure. Membrane Modules. Process Design and applications.

**Specific objectives:**
Distinguish the conditions and requirements of the application of non-porous membranes: removal of dissolved ions and molecules, concentration of streams, separation of target species. The main tools for controlling operation modes including fouling, scaling events. Special attention to selection of cleaning modes including numerical tools and operation tools. The identification of the criteria to identify the use of RO in front of NF or the selection of NF/RO in front of ED and MD. Finally, a familiarization with software for defining RO/NF based process will be completed.

**Related activities:**
Homework assignment: Short exercises
Project on developing a projection for a process using RO/NF using a commercial design tool.

**Full-or-part-time:** 27h
Theory classes: 6h
Guided activities: 4h
Self study : 17h

### 4. Electrical driven membrane processes

**Description:**
Ion Exchange membrane processes. Theoretical Background: chemistry of Ion Exchange Membranes and limiting current potential. Transport phenomena in electro-dialysis applications. System Design and applications
Bipolar-electro-dialysis cells. Theoretical Background of water splitting. Bipolar configurations on acids and bases production. System Design. Applications.

**Specific objectives:**
The students will be able to familiarize to IX membrane properties and their nitration of stacks and the principles of electrical gradients to simplify purification and concentration of streams. The application of bipolar membranes a solution to the production of chemicals as substitution to established precipitation and evaporation technologies will be considered.

**Related activities:**
Homework assignment: Short exercises
Solving problems related to the unit content.
Visit to industrial plants.

**Full-or-part-time:** 29h
Theory classes: 6h
Guided activities: 5h
Self study : 18h

### 5. Chemical Potential and temperature driven membrane processes

**Description:**
Dialysis, Donnan Dialysis and Diffusion Dialysis. Theoretical background. Membranes and Materials. Membrane properties and selectivity patterns. Membrane modules and operation modes. Membrane Fouling Control and Cleaning. Applications.
Membrane Contactors. Carrier facilitated and coupled transport. Theoretical background. Membranes and Materials. Type of hydrophobic membrane categories. Membrane Selectivity. Membrane Modules. Membrane Fouling Control and Cleaning. Applications.
Membrane evaporation Processes. Theoretical background and membranes properties. Temperature and concentration polarization profiles. Membrane Pore wetting and membrane scaling; fouling and control. Applications.

**Specific objectives:**
The student will be able to analyse and estimate the potential uses of chemical and temperature gradients for process separation/concentration and at least four relevant industrial applications will be addressed on terms material selection and operation modes. The student will be able to evaluate the use of hear waste on temperature driven or improving weak chemical potentials by using facilitated or coupled transport solutions.

**Related activities:**
Homework assignment: Short exercises
Solving problems related to the unit content.
Visits to plants.
Co-operative learning approach. Selection and discretization of membrane set-up and mass transfer description of one thermal and chemical potential based industrial example.

**Full-or-part-time:** 33h
Theory classes: 9h
Guided activities: 6h
Self study : 18h

## GRADING SYSTEM

## EXAMINATION RULES.

The standards procedures applying to the Master

## BIBLIOGRAPHY

**Basic:**
- Tanaka, Yoshinobu. Ion exchange membranes : fundamentals and applications. 2nd ed. Amsterdam: Elsevier Science, [2015]. ISBN 9780444633194.
- Baker, Richard W. Membrane technology and applications [on line]. 3rd ed. Chichester, West Sussex: John Wiley, cop. 2012 [Consultation: 12/05/2020]. Available on: https://onlinelibrary.wiley.com/doi/book/10.1002/9781118359686. ISBN 9780470743720.
- Kislik, Vladimir S. (ed.). Liquid membranes : principles and applications in chemical separations and wastewater treatment. Amsterdam ; London: Elsevier, 2010. ISBN 9780444532183.
- Basile, Angelo; Pereira Nunes, Suzana. Advanced membrane science and technology for sustainable energy and environmental applications. Woodhead Publishing, 2011. ISBN 9781845699697.
- Lau,Woei-Jye; Ismail, Ahmad Fauzi; Isloor, Arun; Al-Ahmed, Amir (eds.). Advanced nanomaterials for membrane synthesis and its applications. Amsterdam: Elsevier Science, [2018]. ISBN 9780128145036.

## RESOURCES

**Hyperlink:**

- Water Treatment Online Tools & Calculators. SUEZ. https://www.suezwatertechnologies.com/resources/online-toolsrecurs. • Water Treatment Online Tools & Calculators | SUEZ, https://www.suezwatertechnologies.com/resources/online-tools- The Gateway to Membrane Technology. http://chemeng.in.coocan.jp/GMT/english/indexE. • The Gateway to Membrane Technology, http://chemeng.in.coocan.jp/GMT/english/indexE .

- Dow Chemical : Liquid Separations. Dow Water Academy. https://gateway.on24.com/wcc/gateway/dowwaterandprocessso/906323?partnerref=Customer_Portal. • Dow Chemical: Liquid Separations, Dow Water Academy, https://gateway.on24.com/wcc/gateway/dowwaterandprocessso/906323?partnerref=Customer_Portal- Hydranautics Membrane Projection Tool, Software Hydranautics – A Nitto Group Company. http://membranes.com/solutions/software/om recurs. • Hydranautics Membrane Projection Tool, Software Hydranautics – A Nitto Group Company; http://membranes.com/solutions/software/- MEMSIC 2.0: Membrane Gas Separation Simulator. http://www.colan.org/presentation/memsic-2-0-membrane-gas-separation-simulator/. • MEMSIC 2.0: Membrane Gas Separation Simulator, http://www.colan.org/presentation/memsic-2-0-membrane-gas-separation-simulator/- LewaPlus Software - Liquid Purification Technologies – Lanxess. http://lpt.lanxess.com/lewaplus-software/Nom recurs. • LewaPlus Software - Liquid Purification Technologies – Lanxess, http://lpt.lanxess.com/lewaplus-software/