

Academic Year	2018-2019	Semester	2
Course Coordinator	Asst. Prof. Chong Tzyy Haur		
Course Code	EN4102		
Course Title	Membrane Water Reclamation Technology		
Pre-requisites	Year 3 standing		
No of AUs	3		
Contact Hours	Lecture: 26 hours; Tutorial: 8 hours; Quiz 2 hours; Group-based Project Presentation: 3 hours; e-Learning: 11 hours		
Proposal Date	11 Dec 2018		

Course Aims

This course aims to develop your understanding of membrane technology applied in water reclamation process. You will be familiar with the basic design concepts and able to technically manage a membrane-based water reclamation plant.

Intended Learning Outcomes (ILO)

By the end of this course, you (as a student) should be able to:

1. Discuss the classifications, working principles, and applications of various membrane technologies.
2. Analyse the main factors (feed type, pressure, electrical potential etc.) determining separation performance and energy consumption.
3. Analyse product quality and quantity (rejection and recovery).
4. Relate various membrane plant designs to their advantages and limitations.
5. Apply control on adverse effects in membrane separation process (fouling, scaling, concentration polarisation, etc.)

Course Content

Topic 1: Introduction to Membrane Technology
 Topic 2: Membrane Materials and Synthesis
 Topic 3: Membrane Properties and Characterisation
 Topic 4: Membrane Transport and Rejection
 Topic 5: Membrane Process Design (NF/RO Design)
 Topic 6: Membrane Desalination and Reclamation
 Topic 7: Forward Osmosis and Pressure Retarded Osmosis
 Topic 8: Electrodialysis
 Topic 9: Membrane Distillation
 Topic 10: Membrane Fouling
 Topic 11: Membrane Bioreactor

Assessment (includes both continuous and summative assessment)

Component	Course LO Tested	Related Programme LO or Graduate Attributes	Weighting	Team/ Individual	Assessment rubrics
1. Final Examination	1, 2, 3, 4, 5	ENE SLOs (2018) a, b, c	60%	Individual	Appendix 1

2. Continuous Assessment 1 (CA1): Quiz 1	1, 2, 3	ENE SLOs (2018) a, b, c	10%	Individual	Appendix 1
3. CA2: Quiz 2	1, 2, 3, 4, 5	ENE SLOs (2018) a, b, c	10%	Individual	Appendix 1
4. CA3: Group-based Project	1, 2, 3, 4, 5	ENE SLOs (2018) a, b, c, i	20%	Team	Appendix 2
Total			100%		

Formative feedback

For CA1 and CA2, the questions and solutions will be discussed with you right after the quiz. You will be informed of the median grade and individual grade will be uploaded in NTULearn. For CA3, the topics in Group-based Project will be discussed during the presentation.

Learning and Teaching approach

Approach	How does this approach support students in achieving the learning outcomes?
e-learning	Video lessons provide an overview of the topics. You should complete the video lessons prior to attending the face-to-face lecture.
Lecture	Faculty will elaborate on complex content for deeper learning. You will be able to ask questions when in doubt.
Tutorial	Tutor will guide you in analysing and solving problems.
Group-based Project	Project aims to train you to work in a team, to search for information in the literature, to analyse and to provide critique of what you read or find in the literature.

Reading and References

1. Mulder, M., 'Basic Principles of Membrane Technology', Springer, 1996.
2. Baker, Richard W., 'Membrane Technology and Applications', Wiley, 2012.

Course Policies and Student Responsibilities

(1) General

You are expected to complete all assigned pre-class readings and activities, attend all lectures and tutorials punctually and take all scheduled assignments and quizzes by due dates. You are expected to take responsibility to follow up with course notes, assignments and course related announcements for lectures and tutorials they have missed. You are expected to participate in all lectures and

tutorials discussions and activities.

(2) Absenteeism

CAs make up a significant portion of your course grade. Absence from quizzes and presentation without a valid reason will affect your overall course grade. Valid reasons include falling sick supported by a medical certificate and participation in NTU's approved activities supported by an excuse letter from the relevant bodies. There will be no make-up opportunities for quizzes and presentation.

(3) Project

You are required to submit the project report on due date. Late submission will not be accepted.

Academic Integrity

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the [academic integrity website](#) for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Course Instructors

Instructor	Office Location	Phone	Email
Asst. Prof. Chong Tzyy Haur	N1-01c-91	6513 8126	thchong@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Course LO	Readings/ Activities
Week 1	Topic 1: Introduction to Membrane Technology	1, 2, 3	e-learning: 1 hour Lecture: 2 hours
	Topic 2: Membrane Materials and Synthesis	1, 2, 3	e-learning: 1 hour Lecture: 1 hour

Week 2	Topic 2	1, 2, 3	Lecture: 3 hours
Week 3	Topic 3: Membrane Properties and Characterisation	1, 2, 3	e-learning: 1 hour Lecture: 2 hours
	Topic 1 – 3	1, 2, 3	Tutorial: 1 hour
Week 4	Topic 1 – 3	1, 2, 3	Tutorial: 1 hour
	Topic 4: Membrane Transport and Rejection	1, 2, 3, 4, 5	e-learning: 1 hour Lecture: 2 hours
Week 5	Topic 5: Membrane Process Design (NF/RO Design)	1, 2, 3, 4, 5	e-learning: 1 hour Lecture: 2 hours Tutorial: 1 hour
Week 6	Topic 6: Membrane Desalination and Reclamation	1, 2, 3, 4, 5	e-learning: 1 hour Lecture: 2 hours
	Quiz 1	1, 2, 3	Quiz 1: 1 hour
Week 7	Topic 7: Forward Osmosis and Pressure Retarded Osmosis	1, 2, 3	e-learning: 1 hour Lecture: 2 hours
	Topic 8: Electrodialysis	1, 2, 3	e-learning: 1 hour Lecture: 1 hour
Week 8	Topic 8	1, 2, 3	Lecture: 1 hour
	Topic 4, 6, 7, 8	1, 2, 3, 4, 5	Tutorial: 2 hours
Week 9	Topic 9: Membrane Distillation	1, 2, 3, 4, 5	e-learning: 1 hour Lecture: 2 hours Tutorial: 1 hour
Week 10	Topic 10: Membrane Fouling	1, 2, 3, 4, 5	e-learning: 1 hour Lecture: 3 hours
Week 11	Topic 10	1, 2, 3, 4, 5	Tutorial: 1 hour
	Topic 11: Membrane Bioreactor	1, 2, 3, 4, 5	e-learning: 1 hour Lecture: 2 hours
Week 12	Topic 11	1, 2, 3, 4, 5	Lecture: 1 hour Tutorial: 1 hour
	Quiz 2	1, 2, 3, 4, 5	Quiz 2: 1 hour
Week 13	Group-based Project	1, 2, 3, 4, 5	Presentation and Report

Appendix 1: Assessment Criteria for Final Examination, CA1 and CA2

Performance criteria	Performance Level			
	Outstanding: 4	Good: 3	Average: 2	Poor: 1
Discuss the classifications, working principles, and applications of various membrane technologies.	Excellent knowledge of membrane processes and their working principles, and ability to select membranes and membrane processes	Good knowledge of membrane processes and their working principles, and ability to select membranes for specific applications	General understanding of membrane processes and their working principles	Little understanding of membrane processes and their working principles

	for specific applications			
Analyse the main factors (feed type, pressure, electrical potential etc.) determining separation performance and energy consumption.	Excellent ability to apply basic principles of membrane separation and analyse the main factors affecting separation performance and energy consumption	Good ability to apply basic principles of membrane separation and analyse the main factors affecting separation performance and energy consumption	Able to apply basic principles of membrane separation and energy consumption	Unable to apply basic principles of membrane separation and energy consumption
Analyse product quality and quantity (rejection and recovery).	Excellent ability to quantitatively determine the separation product quality and quantity, able to apply the performance equations all the time	Good ability to quantitatively determine the separation product quality and quantity, able to apply the performance equations most of the time	Able to determine the separation product quality and quantity, know the performance equations	Unable to determine the separation product quality and quantity
Relate various membrane plant designs to their advantages and limitations.	Excellent understanding of membrane layout designs and appreciation of advantages and limitations of given designs, able to present membrane layout unambiguously	Good understanding of membrane layout designs and appreciation of advantages and limitations of given designs	General understanding membrane layout designs	Unable to understand membrane layout designs
Apply control on adverse effects in membrane separation process (fouling, scaling, concentration polarisation, etc.)	Excellent understanding of the cause, consequence, and control technologies of various adverse effects in membrane separation process; able to recommend the right control technology for all the time	Good understanding of the cause, consequence, and control technologies of various adverse effects in membrane separation process; able to recommend the right control technology for most of the time	Able to understand the cause, consequence, and control technologies of various adverse effects in membrane separation process	Unable to understand the cause, consequence, and control technologies of various adverse effects in membrane separation process

Appendix 2: Assessment Criteria for CA3

Performance criteria	Performance Level			
	Outstanding: 4	Good: 3	Average: 2	Poor: 1
Organization and planning of presentation	Excellent coordination and interaction between members during presentation and Q&A. Finish within prescribed time with appropriate pacing.	Equal distribution of presentation load. Good presentation flow between members. Able to answer most of the questions. Finish on time.	Fair distribution of presentation load. Hurriedly finish on time.	Poor distribution of presentation load. Did not finish on time.
Presentation slides and aids	Prepare own diagrams, AV materials etc. to make presentation interesting and meaningful.	Uniform format such as colour, font, slides are numbered etc., make good use of diagram and AV materials etc. to enhance presentation. Properly references all the materials taken from literature.	No typo mistakes, can easily read the slides. Using diagrams, AV materials etc. to enhance presentation to a limited extent.	Overall poor preparation of slides, many typo mistakes, font too small.
Report format and structure	Clear and concise report. All variables in equations are defined and units provided. Quality of pictures/charts is excellent. Citations are clearly referenced. No grammar, spelling, punctuation mistakes.	Good report layout, good presentation of pictures/charts. Citations are referenced. Minor grammar, spelling, punctuation mistakes.	Average report layout, Quality of pictures/charts is fair. Citations are referenced. Some grammar, spelling, punctuation mistakes.	Poor layout, non-uniform format, no references. A lot of grammar, spelling, punctuation mistakes.
Content	In-depth and thorough discussion of topic, provide critical comment, detailed calculations to support claim, show strong evidence of literature search.	Good analysis of information/data, good coverage and discussion of topic, support claim with facts and details, show good evidence of literature search.	Provide sufficient information/data, moderate discussion of topic, show moderate evidence of literature search.	Lacks depth and limited treatment of topics, no clear evidence of literature search.