NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

COURSE CONTENT

Academic Year	2024/2025	**Semester**	1
Course Coordinator	Dr. Poernomo Gunawan / Assoc Prof. Kunn Hadinoto Ong		
Course Code	CH3140		
Course Title	Unit Operations: Fluid-Fluid Separation		
Pre-requisites	CH1104 Materials & Energy Balances, CH2108 Thermodynamics, CH2123/CH3103(old coursecode) Chemical Thermodynamics		
No of AUs	3		
Contact Hours	26 hours lecture, 12 hours tutorial		
Proposal Date	1 Feb 2022		

Course Aims

This course is for the third-year chemical engineering students and aims to cover the principles and fundamental concepts of separation processes, such as binary distillation, absorption and liquid-liquid extraction. You are expected to apply concepts on materials & energy balances as well as chemical engineering thermodynamics to develop, design, and evaluate the performance of these processes.

Intended Learning Outcomes (ILO)

Upon completion of this course, you should be able to:

1) Develop and interpret various phase equilibrium diagrams, such as T-xy, P-xy, ternary diagrams.
2) Derive and apply mass transfer across phases.
3) Design single-stage and multiple-stage separation processes for binary mixtures by using analytical and graphical methods for distillation, absorption and liquid-liquid extraction.
4) Analyse and solve industrial case problems related to separation processes.

Course Content

1. Introduction to separation processes in chemical engineering
2. Thermodynamics concepts on phase equilibrium
3. Phase equilibrium diagrams, bubble points and dew points calculations
4. Single-stage and cascaded flash distillation
5. Design of binary distillation column
6. Design of absorber and stripping columns
7. Design of liquid-liquid extraction column
8. Mass transfer analysis

Assessment (includes both continuous and summative assessment)

Component	Course LO Tested	Related Programme LO or Graduate Attributes	Weighting	Team /Individual	Assessment rubrics
Continuous Assessment: Quiz #1	1, 3	EAB-SLO a), b), c)	15%	Individual	Appendix 1
Continuous Assessment: Take home assignment	1, 3	EAB-SLO a), b), c), d)	5%	Individual	Appendix 1
Continuous Assessment: Industrial case study project	4	EAB-SLO a), b), c), d), i), j)	5%	Team	Appendix 1

Continuous Assessment: Quiz #2	2, 3	EAB-SLO a), b), c)	20%	Individual	Appendix 1
Continuous Assessment: Take home assignment	1, 3	EAB-SLO a), b), c), d)	5%	Individual	Appendix 1
Final Examination [2hrs, Open Book]	1, 2, 3	EAB-SLO a), b), c)	50%	Individual	Appendix 1
Total			100%		

Mapping of Course ILOs to EAB Graduate Attributes

Course Intended Learning Outcomes	Cat	EAB's 12 Graduate Attributes*											
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)
CH2140	Core	●	●	●	◐					š	š		

Develop and interpret various phase equilibrium diagrams, such as T-xy, P-xy, ternary diagrams.	a, b, c
Derive and apply mass transfer across phases.	a, b, c
Design single-stage and multiple-stage separation processes for binary mixtures by using analytical and graphical methods for distillation, absorption and liquid-liquid extraction.	a, b, c, d
Analyse and solve industrial case problems related to separation processes.	a, b, c, d, i, j

Legend:

●	Fully consistent (contributes to more than 75% of Intended Learning Outcomes)
◐	Partially consistent (contributes to about 50% of Intended Learning Outcomes)
š	Weakly consistent (contributes to about 25% of Intended Learning Outcomes)
Blank	Not related to Student Learning Outcomes

Formative feedback

a) Feedback for the assignment will be returned to the students.
b) After each quiz, the solutions will be posted on NTUlearn and students are welcome to set a consultation to address their doubts and misconception.

Learning and Teaching approach

Approach	How does this approach support students in achieving the learning outcomes?
Lecture	Lectures would primarily discuss the fundamentals and concepts of separation process, as well as demonstrate the procedures of solving problems related to separation processes.
Tutorial	Tutorial questions comprise relevant applications of the concepts introduced in lectures. Students are encouraged to have discussion

	with the instructor to clarify doubts and to explore cases beyond the tutorial questions.

Reading and References

1) Wankat, P. C. (1988) *Separation Process Engineering*, 2nd ed. New Jersey: Prentice Hall.
2) Seader, J.D. and Henley, E. J. (2006) *Separation process principles,* 2nd ed.New Jersey; John Wiley.
3) Cussler, E.L., (1997) Diffusion: Mass transfer in fluid systems 2nd ed. New York: Cambridge University Press.
4) McCabe,W. L ., Smith, J. C. and Harriot, P. (2005) Unit operations of chemical engineering, 7th ed. Singapore: McGraw-Hill.
5) Treybal, R.E. (1981) Mass-transfer operations, 3rd ed. Singapore: McGraw-Hill.
6) Perry, R.H., Green, D. W. (1997) Perry's chemical engineers' handbook 7th ed. McGraw-Hill - available online

Course Policies and Student Responsibilities

General: Students are expected to complete all online activities and take all scheduled assignments and tests by due dates. Students are expected to take responsibility to follow up with course notes, assignments and course related announcements. Students are expected to participate in all tutorial discussions and activities.

Continuous assessments: Students are required to attend all continuous assessments.
Absenteeism: Continuous assessments make up a significant portion of students' course grade. Absence from continuous assessments without officially approved leave will result in no marks and affect students' overall course grade.

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
Poernomo Gunawan	N1.2-B2-26A	69081988	pgunawan@ntu.edu.sg
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Planned Weekly Schedule

Week	Topic	Course LO	Readings/ Activities
1	Introduction to separation processes	1	
2	Phase equilibrium	1	
3	Design of single-stage separation process	1, 3	
4	Design of cascaded separation process	1, 3	
5	Design of binary distillation	1, 3	
6	Design of binary distillation	1, 3	
7	Design of complex distillation configurations, open-steam, multiple feed/product streams	1, 3	
8	Industrial case study	4	
9	Design of absorbers and strippers	1, 3	
10	Design of liquid-liquid separation cascades	1, 3	
11	Mass transfer analysis	1, 3	

Appendix 1: Assessment Criteria

Note: For the team case study, in practice each group member would receive the same score. However, it may vary should there be evidence that you have not contributed meaningfully to your team.

Criteria	Unsatisfactory: <40%	Borderline: 40% to 49%	Satisfactory: 50% to 69%	Very good: 70% to 89%	Exemplary: >90 %
Develop and interpret phase equilibrium diagrams	Unable to construct phase equilibrium diagram; unable to determine bubble and dew points even for ideal mixtures, and do not know how to correctly interpret the diagram.	Able to construct phase equilibrium diagram and to determine bubble and dew points for ideal mixtures, but do not know how to correctly interpret and apply the diagram.	Able to construct phase equilibrium diagram, to determine bubble and dew points, and to correctly interpret and apply the diagram for ideal mixtures.	Able to incorporate non-ideal mixtures in constructing phase equilibrium diagram, to determine bubble and dew points, and to correctly interpret and apply the diagram.	Excellent understanding of phase equilibrium for ideal and non-ideal mixtures, including homogeneous and heterogeneous azeotropes.
Design and solve single stage and multiple stage separation process	Unable to visualize and identify the problem and do not know how to develop operating lines required to solve the problem.	Able to visualize and identify the problem and to develop operating lines from materials and energy balances.	Able to visualize and identify the problem, and to construct McCabe-Thiele diagram by using the operating lines to solve the problem.	Good understanding of the problem and fully understand the correlations among operating lines; able to solve the problem by using McCabe-Thiele diagram and mathematical equations.	Excellent understanding of the problem; able to identify complex problems and to solve the problem by using McCabe-Thiele diagram and mathematical equations.
Analyse and solve industrial case problems	Unable to analyze and to formulate the problems and do not know how to apply the principles of separation to solve the problems.	Able to analyze and to formulate the problems but unable to establish correlations between the concept learned in class and the industrial case.	Able to analyze and to formulate the problems and able to apply basic concepts to solve the industrial case problems.	Able to analyze and to formulate the problems and able to articulately apply the concepts to solve the industrial case problems.	Able to analyze and to formulate the problems and able to provide sound recommendations beyond what is expected.

Appendix 2: The EAB (Engineering Accreditation Board) Accreditation SLOs (Student Learning Outcomes)

a) **Engineering knowledge:** Apply the knowledge of mathematics, natural science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems
b) **Problem Analysis:** Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c) **Design/development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
d) **Investigation:** Conduct investigations of complex problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e) **Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations
f) **The engineer and Society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
g) **Environment and Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for the sustainable development.
h) **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
i) **Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary settings.
j) **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
k) **Project Management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and economic decision-making, and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
l) **Life-long Learning:** Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change