NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

COURSE CONTENT

Academic Year	2023/2024	**Semester**	2
Course Coordinator	Prof. Mary Chan Bee Eng		
Course Code	CH2112		
Course Title	Chemical Reaction Engineering		
Pre-requisites	CH1104 Materials & Energy Balances; MH1810 Mathematics 1		
No of AUs	3		
Grading	Letter Grading		
Contact Hours	26 hours of lectures, 12 hours of tutorials		
Proposal Date	6 Oct 2022		

Course Aims

The aim of this course is to support you to apply fundamental concepts and theories of the chemical reaction kinetics to design and analyse a variety of reactor systems in the areas of chemical engineering, particularly: Ideal reactors, isothermal and heterogeneous catalytic reactors.

Intended Learning Outcomes (ILO)

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

1. Interpret and identify chemical reaction engineering problems by formulating appropriate mathematical models;

2. Apply fundamental principles of chemical reactions in qualitative and quantitative manners;

3. Analyse and solve problems by using chemical reaction engineering methods that involve materials and energy balances.

Course Content

1. Introduction to chemical reaction kinetics
2. Isothermal ideal reactors: Batch, plug flow, and continuous stirred tank reactor
3. Concepts of conversion, selectivity and yield for multiple reactions
4. Multiple reactions in continuous ideal reactors
5. Catalytic reactors and mass transfer

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 (50%) (2 hrs, Closed Book)	1, 2, 3	EAB-SLO a), b), c).	50%	Individual	Appendix 1
2. CA1: Quiz 1	1, 2, 3	EAB-SLO a), b), c).	14%	Individual	Appendix 1
3. CA2: Quiz 2	1, 2, 3	EAB-SLO a), b),	24%	Individual	Appendix 1

		c).			
4. Homework	1, 2, 3	EAB-SLO a), b), c).	9%	Individual	Appendix 1
5. Participation	1, 2, 3	EAB-SLO a), b), c).	3%	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)**
	Core	●	●	●									
1. Interpret and identify chemical reaction engineering problems by formulating appropriate mathematical models;		(a), (b), (c)											
2. Apply fundamental principles of chemical reactions in qualitative and quantitative manners;		(a), (b), (c)											
3. Analyse and solve problems by using chemical reaction engineering methods that involve materials and energy balances.		(a), (b), (c)											

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

Formative feedback

After each continuous assessment, 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 reaction kinetic and reactor designs. It would also demonstrate how to carry out a procedure such as working through derivations and examples, using incomplete handouts which enabling students participating in class.
Tutorial	TBL classroom discussion sessions on tutorial questions and related topics.

Reading and References

1) LD Schmidt, The Engineering of Chemical Reactions, Oxford University Press, 1998.
2) Levenspiel, Chemical Reaction Engineering, 3rd Edition, John Wiley and Sons, 1999.
3) H Scott Fogler, Elements of Chemical Reaction Engineering, 3rd Edition, Prentice-Hall International, 1999.

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 Instructor

Instructor	Office Location	Phone	Email
Chan Mary	N1.2-B2-19	67906064	mbechan@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Course LO	Readings/ Activities
1	Introduction & chemical reaction kinetics	1	Schmidt Chpt 1
2	Batch reactor design	1, 2, 3	Schmidt Chpt 2
3	Batch rector design		Schmidt Chpt 2
4	Continuous reactors (Plug flow & Continuous stirred tank reactor)	1, 2, 3	Schmidt Chpt 3
5	Continuous reactors (Plug flow & Continuous stirred tank reactor)	1, 2, 3	Schmidt Chpt 3
6	Multiple reactors	1, 2	Schmidt Chpt 3
7	Multiple reactors	1, 2	Schmidt Chpt 3
8	Multiple reactions in continuous and batch reactors	1, 2, 3	Schmidt Chpt 4
9	Multiple reactions in continuous and batch reactors	1, 2, 3	Schmidt Chpt 4
10	Multiple reactions in continuous and batch reactors	1, 2, 2	Schmidt Chpt 4
11	Heterogeneous catalytic reactions	1, 2, 3	Schmidt Chpt 7
12	Heterogeneous catalytic reactors and mass transfer	1, 2, 3	Schmidt Chpt 7
13	Heterogeneous catalytic reactors and mass transfer	1, 2, 3	Schmidt Chpt 7

Appendix 1: Assessment Criteria

Criteria	Unsatisfactory: <40%	Borderline: 40% to 49%	Satisfactory: 50% to 69%	Very good: 70% to 89%	Exemplary: >90%
Apply material balances for single reaction to single isothermal reactor design	Unable to analyse and identify the problem; unable to apply the materials balance for different types of isothermal reactors	Able to develop expressions of the material balance for various isothermal reactors: batch, PFR and CSTR	Able to develop and solve the material balance for various isothermal reactors: batch, PFR and CSTR, to find the reactor volume and conversion.	Able to incorporate and solve various reaction kinetics for single irreversible reactions into materials balance for various types of isothermal reactors.	Able to incorporate and solve various reaction kinetics for single irreversible and reversible reactions into materials balances for single isothermal reactors. Able to perform analysis on the equilibrium conversion.
Apply material & energy balances for multiple reactions to single isothermal reactor design	Unable to analyse and identify the problem; unable to apply the materials balance for multiple reactions using different types of single isothermal reactors	Able to develop expressions of the material balance of multiple reversible and irreversible reactions for various single isothermal reactors: batch, PFR and CSTR	Able to develop and solve the material balance of multiple reversible and irreversible reactions for various single isothermal reactors: batch, PFR and CSTR, to find the reactor volume and conversion.	Able to incorporate and solve various reaction kinetics for multiple irreversible and reversible reactions into materials balance for various types single isothermal reactors.	Able to incorporate and solve various reaction kinetics for multiple irreversible and reversible reactions into materials balances for isothermal reactor system.
Apply material & energy balances for isothermal multi-reactor system design	Unable to analyse and identify the problem; unable to apply the materials balance for combinations of different types of isothermal reactors	Able to develop expressions of the material balance for isothermal reactor combination system involving multiple reactors of batch, PFR and CSTR	Able to develop and solve the material balance for various isothermal reactors combination system involving batch, PFR and CSTR, to find the reactor system volumes and conversions.	Able to incorporate and solve various reaction kinetics for single irreversible reactions into materials balance for various reactor combination types involving isothermal reactors.	Able to incorporate and solve various reaction kinetics for single irreversible and reversible reactions into materials balances for combinations of isothermal reactors. Able to perform analysis on the equilibrium conversion.

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