NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

COURSE CONTENT

Academic Year	2022/2023	**Semester**	2
Course Coordinator	Assoc. Prof. Lee Jong Min / Prof. Xu Rong		
Course Code	CH2114		
Course Title	Heat and Mass Transfer in Chemical and Biological Systems		
Pre-requisites	Nil		
No of AUs	3		
Contact Hours	*26 hours lecture, 12 hours tutorial*		
Proposal Date	05/07/2022		

Course Aims

The course aims to enable you to understand the meaning of the terminology and physical principles of heat and mass transfer. You are taught to compute heat and mass transfer rate and/or temperature and concentration distribution for processes involving heat and mass transfer, when requisite conditions are given. You are taught to develop representative models of real processes and system (e.g. heat exchanger) and to draw conclusion from analysis. This course develops your ability to independently critically analyse complex systems and develop mathematical models to predict the behaviour of these systems.

Intended Learning Outcomes (ILO)

Upon completion of the course, you should be able:

1. Describe and differentiate fundamental theories and applications of heat and mass transport phenomena (emphazing their anaologies and contrasts).
2. Interpret Fourier's law, steady and unsteady thermal conduction, heat transfer coefficients, heat exchangers, condensation and boiling, radiation, Fick's law, steady and unsteady diffusion, mass transfer coefficients, absorbers, simultaneous heat and mass transfer.
3. Develop representative models of real processes and system (e.g. heat exchanger) and to draw conclusion from analysis.

Course Content

Fundamentals of heat transfer (conduction, convection and radiation), Fourier's law, steady and unsteady thermal conduction, heat transfer coefficients, transient heat conduction, heat transfer by convection, heat exchangers, Fick's law, steady and unsteady diffusion, mass transfer coefficients, absorbers, simultaneous heat 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 (60%) *(2hrs; Open Book)*	1,2,3	a, b, c, d	60%	Individual	See Appendix 1
2. Continuous Assessment (40%) a. Quiz 1 Heat Transfer 1 (18%) b. Heat transfer essay (6%)	1,2,3	a, b, c, d	24%	Individual	See Appendix 1
c. Quiz 2 or assignments Mass Transfer (16%)	1,2,3	a, b, c, d	16%	Individual	See 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)
CH2114	Core	●	●	●	●						š		
Describe and differentiate fundamental theories and applications of heat and mass transport phenomena (emphazing their anaologies and contrasts).											a,b,c,d		
Interpret Fourier's law, steady and unsteady thermal conduction, heat transfer coefficients, convection heat transfer, heat exchangers, radiation, Fick's law, steady and unsteady diffusion, mass transfer coefficients, absorbers, simultaneous heat and mass transfer.											a,b,c,d		
Develop representative models of real processes and system (e.g. heat exchanger) and to draw conclusion from analysis											a,b,c,d		

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

Examination results;
Marker's report on overall examination performance will be uploaded to NTUlearn;
Quiz answers will be discussed in class

Learning and Teaching approach

Approach	How does this approach support students in achieving the learning outcomes?
Lecture	Demonstrate how to carry out a procedure such as working through a problem. Derivations of fundamental equations are done. We use incomplete handouts to enable students to participate in class.
Tutorial	Classroom discussion sessions on tutorial questions and related topics.

Reading and References

1) Frank P. Incropera and David P. DeWitt, Incropera's Principles of Heat and Mass Transfer, 1st Edition, Global edition, Wiley, 2020.
2) Welty, Wicks, Wilson and Rorrer, Fundamentals of Momentum, Heat, and Mass Transfer, 5rd Edition, John Wiley & Sons, 2008.
3) Kreyszig, Advanced Engineering Mathematics, 10th Edition
4) Dean, Analysis of Transport Phenomenon
5) Farlow, Partial differential equations for scientists and engineers

Course Policies and Student Responsibilities

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

Absenteeism:
Continuous assessments make up a significant portion of your course grade. Absence from continuous assessments without officially approved leave will result in no marks and affect your 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
Lee Jong Min	N1.2-B1-21	65138129	JMLEE@ntu.edu.sg
Xu Rong	N1.2-B1-10	6790 6713	rxu@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Course LO	Readings/ Activities
1	Fundamentals of heat transfer	1,2	Text/Tutorials/Lecture
2	Fourier's law and the heat equation	1,2	Text/Tutorials/Lecture
3-5	Steady-state heat conduction	1,2,3	Text/Tutorials/Lecture
6	Transient heat conduction	1,2,3	Text/Tutorials/Lecture
7-8	Heat convection and heat exchanger	1,2,3	Text/Tutorials/Lecture
9-10	Fundamentals of mass transfer	1,2,3	Text/Tutorials/Lecture
11	Mass transfer equations	1,2,3	Text/Tutorials/Lecture
12	Molecular diffusion	1,2,3	Text/Tutorials/Lecture
13	Mass transfer problems	1,2,3	Text/Tutorials/Lecture

Appendix 1: Assessment Criteria

ILO	Unsatisfactory : 1	Borderline: 2	Satisfactory: 3	Very good: 4	Exemplary: 5
Understand the basic concepts of heat and mass transfer	Lacks understanding of theories, laws, concepts and terms governing basic heat and mass transfer Unable to apply the theories and concepts to simple problems of heat and mass transfer	Partial understanding of theories, laws, concepts and terms governing basic heat and mass transfer Able to apply the theories and concepts to simple problems of heat and mass transfer	Full understanding of theories, laws, concepts and terms governing basic heat and mass transfer Able to apply the theories and concepts to some problems of heat and mass transfer	Deep and complete understanding of theories, laws, concepts and terms governing basic heat and mass transfer Able to apply the theories and concepts to most problems of heat and mass transfer Able to solve most quantitative problems of heat and mass transfer	Deep and complete understanding of theories, laws, concepts and terms governing basic heat and mass transfer Able to apply the theories and concepts to all problems of heat and mass transfer Able to solve all quantitative problems of heat and mass transfer
Apply the concepts of heat and mass transfer to predict temperature or concentration profiles	Unable to apply theoretical concepts of heat and mass transfer to simple heat and mass transfer processes	Able to partially apply theoretical concepts of heat and mass transfer to simple heat and mass transfer processes	Able to apply theoretical concepts of heat and mass transfer to basic heat and mass transfer processes in simple systems	Able to apply theoretical concepts of heat and mass transfer to basic heat and mass transfer processes in more complex systems	Able to apply theoretical concepts of heat and mass transfer to advanced heat and mass transfer processes in complex systems
Use concepts of heat and mass transfer to calculate unknown properties of the system (e.g., transfer coefficients)	Calculations are attempted but are unsuccessful and not comprehensive	Calculations are attempted but represent only a portion of the calculations required with some comprehensive to solve the problem	Calculations attempted are mostly successful and sufficiently comprehensive to solve the problem	Calculations attempted are all successful and sufficiently comprehensive to solve the problem	Calculations attempted are all successful and fully comprehensive to solve the problem Calculations are presented elegantly
Analyze heat and mass transfer in various systems to interpret behavior of systems	Quantitative analysis of data is used for basic, yet uncertain, judgments. Unable to draw conclusions from work.	Quantitative analysis of data is used for basic, yet uncertain, judgments. Able to draw some conclusions from work.	Quantitative analysis of data is used for basic judgments. Able to draw accurate conclusions from work.	Quantitative analysis of data is used for judgments. Able to draw accurate and insightful conclusions from work.	Quantitative analysis of data is used for deep and meaningful judgments. Able to draw accurate and insightful conclusions from work.

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