NANYANG TECHNOLOGICAL UNIVERSITY

COURSE CONTENT

Academic Year	2022/2023	**Semester**	1
Course Coordinator	Assoc Prof. Liu Bin		
Course Code	CH2108		
Course Title	Thermodynamics		
Pre-requisites	CH1104		
No of AUs	3		
Contact Hours	26 hours lecture, 13 hours tutorial		
Proposal Date	22/10/2019		

Course Aims

In this course, you will learn the conceptual forms of energy, ideal gas, thermodynamics properties, and the laws of thermodynamics. The applications of thermodynamics are studied in terms of different phases and their coexistence via phase equilibria and mathematical formula, which will be derived from the 1st and 2nd laws of thermodynamics. In particular, the phase equilibria criteria are introduced to understand the occurrence of the phase separation.

Intended Learning Outcomes (ILO)

Upon the successful completion of the course, you should be able to:

1. Describe basic concepts and properties of thermodynamics and associated measurement processes.
2. Outline the three laws of thermodynamics.
3. Apply the first and second laws of thermodynamics (mathematical statements) to derive correct equations or formulas for solving relevant problems.
4. Explain the dynamics and properties of fluid and gaseous conditions and associated laws.
5. Explain phase equilibria concepts and associated laws.

Course Content

1. Introduction to Thermodynamics
2. The First Law of Thermodynamics
3. Volumetric Properties of Pure Fluids
4. The Second Law of Thermodynamics
5. Calculus of Thermodynamics
6. Vapor-Liquid Equilibrium
7. Residual Properties

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 (2.5 hrs, open book)	Exam questions will be evenly distributed across the course contents including 1st and 2nd laws of thermodynamics, calculus of thermodynamics, vapor-liquid equilibrium and etc to meet the course LO 1 to 5.	EAB SLO (a), (b), (c), (d), (g)	60%	Individual	Appendix 1 (Learned Knowledge) Understanding of basic laws of thermodynamics such as 1st and 2nd law of thermodynamics. (Application) Applying thermodynamic concepts to thermodynamic systems. (Calculations) Design thermodynamic processes. (Analysis) Analyze thermodynamic processes using 1st and 2nd law
2. Continuous Assessment - Quiz	Quiz questions will be evenly distributed across the course contents including 1st and 2nd laws of thermodynamics to meet the course LO 1 to 2.	EAB SLO (a), (b), (c), (d)	40%	Individual	Appendix 1 (Learned Knowledge) Understanding of basic laws of thermodynamics such as 1st and 2nd law of thermodynamics. (Application) Applying thermodynamic concepts to thermodynamic systems. (Analysis) Analyze thermodynamic processes using 1st and 2nd law
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	●	●	●	●			◐		š	š		

1. Describe basic concepts and properties of thermodynamics and associated measurement processes.	(a), (b), (c), (d)
2. Outline the three laws of thermodynamics.	(a), (b), (c), (d)
3. Apply the first and second laws of thermodynamics (mathematical statements) to derive correct equations or formulas for solving relevant problems.	(a), (b), (c), (d), (i), (j)
4. Explain the dynamics and properties of fluid and gaseous conditions and associated laws.	(a), (b), (c), (d), (g), (i), (j)
5. Explain phase equilibria concepts and associated laws.	(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, use incomplete handouts which enabling students participating in class.
Tutorial	TBL classroom discussion sessions on tutorial questions and related topics

Reading and References

1) Smith, J.M., Van Ness, H.C., and Abbott, M.M., Introduction of Chemical Engineering Thermodynamics, McGraw Hill, 7th ed. in SI units (2005).
2) Sandler, S.I., Chemical, Biochemical, and Engineering Thermodynamics, 4th ed., Wiley (2006).
3) Elliot, J.R and Lira, C.T., Introductory Chemical Engineering Thermodynamics, 2nd ed., Prentice Hall PTR (2012).
4) Rogers, G.F.C. and Mayhew, Y.R., Thermodynamic and Transport Properties of Fluids (SI units), 5th ed., Oxford Basil Blackwell (1995).
5) Handbook of Chemistry and Physics, 93rd Ed., Lied, D.R., ed.; CRC press: Boca Raton (2012).

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
Liu Bin	N1.2 B1-06	65137971	LiuBin@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Course LO	Readings/ Activities
1	Introduction to Thermodynamics	1. Describe basic concepts and properties of thermodynamics. 2. Define different formless quantities and measurement units of thermodynamics.	Reading textbooks and lecture notes, and watching online videos.
2	The First Law of Thermodynamics	1. Explain the First Law of Thermodynamics and the associated processes. 2. Apply mathematical equation of the first law for relevant problem scenarios.	Reading textbooks and lecture notes, and play online mini-games.
3-4	Volumetric Properties of Pure Fluids	1. Recognize the different volumetric properties of pure fluids in relation to given pressure and temperature conditions.	Reading textbooks and lecture notes, and watching online videos.

		2. Apply relevant equation to find out required values for given fluid conditions. 3. Explain ideal gas and associated processes and equations. 4. Apply relevant equations to find out required values for given ideal gas conditions.	
5-7	The Second Law of Thermodynamics	1. Explain concepts of Reversibility. 2. Outline the functional steps of a Heat Engine and Ideal Carnot Cycle. 3. Explain the Second Law of Thermodynamics. 4. Apply the second law mathematical statement to derive equations to solve relevant problems. 5. State third law of thermodynamics.	Reading textbooks and lecture notes, and watching online videos.
8-10	Calculus of Thermodynamics	Apply calculus of thermodynamics functions and variables to find required properties in given thermodynamics problems.	Reading textbooks and lecture notes.
11-12	Vapor-Liquid Equilibrium	1. Explain phase equilibria concepts and associated laws. 2. Apply the relevant laws to derive correct equations for problem solving.	Reading textbooks and lecture notes, and watching online videos.
13	Residual Properties	1. Describe residual properties and property relations. 2. Explain relevant methods and equations to evaluate residual properties.	Reading textbooks and lecture notes.

Appendix 1: Assessment Criteria

Criteria	Unsatisfactory: <40%	Borderline: 40% to 49%	Satisfactory: 50% to 69%	Very good: 70% to 89%	Exemplary: >90%
(Learned Knowledge) Understanding of basic laws of thermodynamics such as 1st and 2nd law of thermodynamics.	Lacks understanding of theories, laws, concepts and terms of thermodynamics Unable to apply the theories and concepts to simple problems of thermodynamics such as processes involving change of states.	Partial understanding of theories, laws, concepts and terms of thermodynamics Able to apply the theories and concepts to simple problems of thermodynamics such as processes involving change of states	Full understanding of theories, laws, concepts and terms of thermodynamics Able to apply the theories and concepts to most problems of thermodynamic processes involving heat transfer and work done	Deep and complete understanding of theories, laws, concepts and terms of thermodynamics Able to apply the theories and concepts to most problems of thermodynamic processes involving change of states, heat transfer and work done	Deep and complete understanding of theories, laws, concepts and terms of thermodynamics Able to apply the theories and concepts to all problems of thermodynamic processes involving change of states, heat transfer and work done
(Application) Applying thermodynamic concepts to thermodynamic systems.	Unable to understand theoretical concepts of thermodynamics and apply the knowledge to design and optimize simple thermodynamic processes	Able to partially understand theoretical concepts of thermodynamics but unable to apply the knowledge to design and optimize simple thermodynamic processes	Able to understand theoretical concepts of thermodynamics and apply the knowledge to design and optimize simple thermodynamic processes	Able to understand theoretical concepts of thermodynamics and apply the knowledge to design and optimize medium level thermodynamic processes	Able to understand theoretical concepts of thermodynamics and apply the knowledge to design and optimize complex thermodynamic processes
(Calculations) Design thermodynamic processes.	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
(Analysis) Analyze thermodynamic processes using 1st and 2nd law	Use the quantitative analysis of data as the basis for tentative, basic judgments, although is hesitant or uncertain about drawing conclusions from this work	Use the quantitative analysis of data as the basis for ordinary judgments, drawing plausible conclusions from this work	Use the quantitative analysis of data as the basis for competent judgments, drawing reasonable and appropriately qualified conclusions from this work	Use the quantitative analysis of data as the basis for competent judgments, drawing insightful and qualified conclusions from this work	Use the quantitative analysis of data as the basis for deep and thoughtful judgments, drawing insightful and carefully qualified conclusions from this 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