City University of Hong Kong
Course Syllabus

offered by Department of Materials Science and Engineering
with effect from Semester A 2024/25

Part I Course Overview

Course Title:	**Thermodynamics of Materials**
Course Code:	**MSE5304**
Course Duration:	**One semester**
Credit Units:	**3**
Level:	**P5**
Medium of Instruction:	**English**
Medium of Assessment:	**English**
Prerequisites: *(Course Code and Title)*	**Nil**
Precursors: *(Course Code and Title)*	**Nil**
Equivalent Courses: *(Course Code and Title)*	**Nil**
Exclusive Courses: *(Course Code and Title)*	**Nil**

Part II Course Details

1. Abstract

The course aims at covering the basic principles of thermodynamics and the applications of those principles in engineering practice and in materials science. Upon successful completion of the course, students are expected to be equipped with sufficient knowledge to analyse simple thermodynamic cycles as well as to describe and to determine the equilibrium states of a material.

2. Course Intended Learning Outcomes (CILOs)

(CILOs state what the student is expected to be able to do at the end of the course according to a given standard of performance.)

No.	CILOs	Weighting* (if applicable)	Discovery-enriched curriculum related learning outcomes (please tick where appropriate)		
			A1	*A2*	*A3*
1.	Analyze quantitatively the conversions among heat, work and energy in different processes using the 1st Law of Thermodynamics.			√	
2.	Describe the concepts of irreversible processes in terms of entropy generation and the 2nd Law of Thermodynamics.			√	
3.	Describe and analyze quantitatively the operating principles of heat engines and heat pumps, including the idealized devices based on Carnot cycle.			√	
4.	Explain the features in binary phase diagrams based on the 'Conditions for Equilibrium' and apply the mass and energy balances to reacting systems and describe conditions for chemical equilibrium.			√	
5.	Identify major applications of thermodynamics of materials and design creative solutions for different applications				√
** If weighting is assigned to CILOs, they should add up to 100%.*		100%			

A1: Attitude
Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability
Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

A3: *Accomplishments*
Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

3. Learning and Teaching Activities (LTAs)

(LTAs designed to facilitate students' achievement of the CILOs.)

LTA	Brief Description	CILO No.						Hours/week (if applicable)
		1	2	3	4	5		
1	Large Class Activities (Lecture/Tutorial)	√	√	√	√	√		3 hrs/week
2	Experiment/video demonstration	√	√	√	√	√		0.5 hr/week

4. Assessment Tasks/Activities (ATs)

(ATs are designed to assess how well the students achieve the CILOs.)

Assessment Tasks/Activities	CILO No.						Weighting*	Remarks
	1	2	3	4	5			
Continuous Assessment: 40%								
Assignment	√	√	√	√	√		5%	Take-home or in-class assignments
Mid-term test	√	√	√	√	√		20%	
Report/Essay	√	√	√	√	√		15%	Students will engage in writing reports/essays for experiment/video demonstrations, or analysis of original research publications to generate work with new concepts
Examination (duration: 2 hours)	√	√	√	√	√		60%	
** The weightings should add up to 100%.*							100%	

5. Assessment Rubrics

(Grading of student achievements is based on student performance in assessment tasks/activities with the following rubrics.)

Applicable to students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B, B-)	Fair (C+, C, C-)	Marginal (D)	Failure (F)
1. Examination	Able to solve numerical problems, and demonstrate the understanding of basic principles	High	Significant	Moderate	Basic	Not even reaching marginal levels
2. Report/essay	Ability to explain the methodology and to analyse the data	High	Significant	Moderate	Basic	Not even reaching marginal levels
3. Mid-term test	Ability to explain scientific principles and to solve related problems	High	Significant	Moderate	Basic	Not even reaching marginal levels
4. Assignment	Ability to sum up, to assess, and to comment on the work of their peers	High	Significant	Moderate	Basic	Not even reaching marginal levels

Applicable to students admitted from Semester A 2022/23 to Summer term 2024

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B)	Marginal (B-, C+, C)	Failure (F)
1. Examination	Able to solve numerical problems, and demonstrate the understanding of basic principles	High	Moderate	Basic	Not even reaching marginal levels
2. Report/essay	Ability to explain the methodology and to analyse the data	High	Moderate	Basic	Not even reaching marginal levels
3. Mid-term test	Ability to explain scientific principles and to solve related problems	High	Moderate	Basic	Not even reaching marginal levels
4. Assignment	Ability to sum up, to assess, and to comment on the work of their peers	High	Moderate	Basic	Not even reaching marginal levels

Part III Other Information (more details can be provided separately in the teaching plan)

1. Keyword Syllabus

- Introduction

  Systems and surroundings, state functions, process variables, extensive and intensive properties.

- The 1st laws of thermodynamics

  Internal energy, heat, work, the closed and open systems, temperature and Zeroth law of thermodynamics, enthalpy, steady state, heat capacities, the 1st law of thermodynamics, kinetic theory of gas, ideal gas.

- The 2nd law of thermodynamics and heat engines

  2nd law of thermodynamics, entropy, reversible and irreversible processes, Carnot cycle, heat engines and efficiency, heat pump and coefficient of performance, statistical view of entropy.

- Thermodynamic Variables and Property relationships

  Free energies, chemical potentials, heat capacities, coefficient of thermal expansion, compressibility, coefficient relations, Maxwell relations.

- Equilibrium

  Equilibrium state vs. steady state, Criterion for equilibrium, Conditions for equilibrium, phase equilibrium in a unary two-phase system.

- Phase rule and phase diagrams

  Phases, components, equilibrium conditions, Gibbs phase rule, unary system, The Clausius-Clapeyron equation, solid solutions, entropy of mixing, ideal solution, regular solution, equilibrium in multi-component heterogeneous system, binary phase diagrams.

- Chemical reactions

  Chemical internal energy, Combustion reaction, Chemical equilibrium

2. Reading List

2.1 Compulsory Readings

(Compulsory readings can include books, book chapters, or journal/magazine articles. There are also collections of e-books, e-journals available from the CityU Library.)

Nil

2.2 Additional Readings

(Additional references for students to learn to expand their knowledge about the subject.)

1.	Yunus A Çengel, Michael A Boles, "Thermodynamics – An Engineering Approach", 6th ed. In SI units, McGraw-Hill, 2008. (Call no.: TJ265 C43 2008; ISBN 007-125084-0).
2.	David V Ragone, "Thermodynamics of Materials", New York, Wiley, 1995. (call no.: TA418.52.R34 1995, v.1 and 2).
3.	Robert T DeHoff, "Thermodynamics in Materials Science", New York, McGraw-Hill, 1993. (call no.: TA403.6.D44 1993).
4.	D A Porter and K E Easterling, "Phase Transformations in Metals and Alloys", 2nd ed., CRCPress, 2001.
5.	D.R. Gaskell, "Introduction to the Thermodynamics of Materials"