City University of Hong Kong
Course Syllabus

offered by Department of Materials Science and Engineering
with effect from Semester A 2022/23

Part I Course Overview

Course Title:	**Phase Transformation in Materials**
Course Code:	**MSE8014**
Course Duration:	**One semester**
Credit Units:	**3**
Level:	**R8**
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

This course is designed to equip students with fundamental knowledge on analysing basic processes during changes in material compositions, phases and microstructures. The course will first briefly review the essential thermodynamics and mathematics background, including key concepts such as entropy, free energy, driving force, coupling and flux. Both continuum and atomistic models of diffusion, as well as their quantitative analysis will then be covered. Emphasis will be placed on diffusion in crystals and along crystal imperfections such as dislocation, surface and grain boundaries. Motion of dislocation, surface and interface during microstructure evolution will also be covered. General features of phase transformation, nucleation and growth theory, concurrent nucleation and growth will be addressed. Finally, the course will introduce a few selected topics such as solidification, precipitation and martensitic transformation. Together, the course will establish a firm foundation for graduate research work in materials science and engineering.

2. Course Intended Learning Outcomes (CILOs)

No.	CILOs	Weighting* (if applicable)	Discovery-enriched curriculum related learning outcomes (please tick where appropriate)		
			A1	*A2*	*A3*
1.	Understand the driving force and kinetics of material processes.	10%	√		
2.	Understand and analyze the mechanism and models of diffusion and atomistic scales.	25%		√	
3.	Understand and analyze the motion of interfaces during microstructure evolution.	25%		√	
4.	Understand the details of various phase transformation mechanisms, including nucleation, growth and coarsening.	25%		√	
5.	Explore the application aspects related to kinetic processes and phase transformation.	15%			√
		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 self-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. Teaching and Learning Activities (TLAs)

TLA	Brief Description	CILO No.					Hours/week (if applicable)
		1	2	3	4	5	
Lecture	PPT and/or video presentation	√	√	√	√	√	2 hrs/week
Tutorial and Group Discussion			√	√	√		1 hr/week

4. Assessment Tasks/Activities (ATs)

Assessment Tasks/Activities	CILO No.					Weighting*	Remarks
	1	2	3	4	5		
Continuous Assessment: 40%							
Assignment				√	√	20%	
Mid-term test	√	√	√			20%	
Examination: (duration: 2 hours)	√	√	√	√		60%	
						100%	

5. Assessment Rubrics

Applicable to students admitted in Semester A 2022/23 and thereafter

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B)	Marginal (B-, C+, C)	Failure (F)
1. Assignment	Ability to practise the in-depth understanding of the related knowledge	High	Moderate	Basic	Not even reaching marginal levels
2. Mid-term test	Ability to practise the in-depth understanding of the related knowledge	High	Moderate	Basic	Not even reaching marginal levels
3. Examination	Capability to explain and analyze the kinetics and mechanisms related to different stages of various kinetic and phase transformation processes	High	Moderate	Basic	Not even reaching marginal levels

Applicable to students admitted before Semester A 2022/23

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B, B-)	Adequate (C+, C, C-)	Marginal (D)	Failure (F)
1. Assignment	Ability to practise the in-depth understanding of the related knowledge	High	Significant	Moderate	Basic	Not even reaching marginal levels
2. Mid-term test	Ability to practise the in-depth understanding of the related knowledge	High	Significant	Moderate	Basic	Not even reaching marginal levels
3. Examination	Capability to explain and analyze the kinetics and mechanisms related to different stages of various kinetic and phase transformation processes	High	Significant	Moderate	Basic	Not even reaching marginal levels

Part III Other Information

1. Keyword Syllabus

- Fundamentals of phase transformation, such as thermodynamics and kinetics, coupled forces and fluxes
- Driving forces and fluxes for diffusion, self-diffusion and interdiffusion, etc.
- Diffusion equation and solutions to diffusion equation
- Diffusion in multicomponent systems
- Atomic models for diffusion
- Diffusion in crystals and along crystal imperfections, e.g., dislocation, grain boundary and surface diffusion
- Motion of dislocation, surface and interface
- Surface evolution and coarsening of particles and grains, effects of capillarity and elasticity
- General features of phase transformation
- Homogeneous and heterogeneous nucleation and growth
- Concurrent nucleation and growth, TTT (Time-Temperature-Transformation) diagrams
- Solidification
- Precipitation
- Diffusionless phase transformation, massive transformation and martensitic transformation

2. Reading List

2.1 Compulsory Readings

1.	Kinetics of Materials, RW Balluffi, SM Allen, WC Carter, Wiley & Sons, New Jersey.
2.	Diffusion in Solids, PG Shewmon, McGraw-Hill Book Company, New York.
3.	Transformations in metals, PG Shewmon, McGraw-Hill, New York.
4.	Phase Transformations in Metals and Alloys, DA Potter, KE Easterling, Chapman and Hall.
5.	The Theory of Transformations in Metals and Alloys, JW Christian, Pergamon Press, Oxford.

2.2 Additional Readings

1.	Physical Metallurgy Principles, RE Reed-Hill and R Abbaschian, PWS-KENT Pub, Boston.
2.	Thermodynamics and Kinetics of Phase Transformations (MRS Proc. Vol. 398), AL Greer, JS Im, BW Park, GB Stephenson, MRS.