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:	**Structural Properties of Materials**
Course Code:	**MSE8020**
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 aims to provide graduate students with a solid foundation in the structural properties of materials. It covers the structure of crystalline materials and imperfections (including point defects, dislocations and interfaces). Emphasis will be placed upon how the structural characteristics determine structural properties. The course discusses three structural properties in detail – elasticity, plasticity and fracture. Each of these properties will be derived from the knowledge of material structure and physical principles with mathematical tools. To this end, the course also introduces the necessary theories of continuum mechanics and micromechanics. Upon completion of the course, students will have gained an in-depth understanding of material structure and the associated structural properties. They will also acquire the ability to perform quantitative analysis in their research.

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.	Describe physical quantities and formulate physical principles using vector/tensor notations, algebra, and analysis.	10%		√	
2.	Analyse the structure of crystalline materials by examining close packing, coordination polyhedra, and symmetry operations (point group, plane group and space group).	20%		√	√
3	Derive the constraints on material properties by analysing material structure, bonding character, and the fundamental principles of physics.	20%	√	√	
4.	Analyse and/or predict the deformation and structural failure of materials based on the structure and dynamics of defects (including point defects, dislocations, interfaces and cracks).	30%	√	√	√
5.	Evaluate the strengthening effect based on the mechanisms that involve the interaction between different defects.	20%		√	√
	* *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	
Lecture	Students will engage in formal lectures to gain knowledge about vector/tensor (notations, algebra and analysis), physical principles, description of material structure, relationship between material structure and mechanical properties, defects in materials, and strengthening mechanism.	√	√	√	√	√	2
Tutorial	Students will engage in tutorial activities to apply the knowledge gained from the lectures to solve the practical problems and to present the results by programming and plotting.	√	√	√	√	√	1

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: 50%							
Homework	√	√	√	√	√	30%	
Midterm	√	√	√	√		20%	
Examination: 50% (duration: 2 hrs)	√	√	√	√	√	50%	
** 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. Homework	Students can describe physical quantities and formulate physical principles using vector/tensor notations, algebra, and analysis, analyse the structure of crystalline materials, derive the theories of elasticity and plasticity, and apply the knowledge gained from the lectures to solve problems.	High	Significant	Moderate	Basic	Not even reaching the marginal levels
2. Midterm	Students can explain the basic concepts and perform quantitative analysis of material structure and elastic problems.	High	Significant	Moderate	Basic	Not even reaching the marginal levels
3. Examination	Students can explain plastic behaviour of materials based on the structure and dynamics of defects, perform quantitative analysis on strengthening and fracture of materials.	High	Significant	Moderate	Basic	Not even reaching the 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. Homework	Students can describe physical quantities and formulate physical principles using vector/tensor notations, algebra, and analysis, analyse the structure of crystalline materials, derive the theories of elasticity and plasticity, and apply the knowledge gained from the lectures to solve problems.	High	Moderate	Basic	Not even reaching the marginal levels
2. Midterm	Students can explain the basic concepts and perform quantitative analysis of material structure and elastic problems.	High	Moderate	Basic	Not even reaching the marginal levels
3. Examination	Students can explain plastic behaviour of materials based on the structure and dynamics of defects, perform quantitative analysis on strengthening and fracture of materials.	High	Moderate	Basic	Not even reaching the marginal levels

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

1. Keyword Syllabus

(An indication of the key topics of the course.)

Prerequisite

1. Tensor, Transformation, Material Property

Part I Crystal Structure, Atomic Bonding, Elasticity

Deformation of Materials

2. Description of Deformation
3. Physical Principles

Materials of Focus: Crystals

4. Packing, Coordination Polyhedra, Compounds
5. Atomic Bonding
6. Symmetry

"Small" "Elastic" Deformation of "Crystals"

7. Elastic Response

Part II Defect Structure, Defect Kinetics, Plasticity

Defects in Crystals

8. Defects in Crystals

Microelasticity

9. Eshelby's Inclusion: A Brief Introduction

Defects + Elasticity = Plasticity

10. A Single Dislocation
11. Crystal Plasticity
12. Defect Interaction: Strengthening
13. Fracture

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.)

1	Lecture notes
2	Tutorial questions
3	Selected journal articles

2.2 Additional Readings

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

1	Crystals, Defects and Microstructures, R. Phillips, Cambridge University Press, 2004
2	An Introduction to Continuum Mechanics, J. N. Reddy, Cambridge University Press, 2007
3	The Mechanics and Thermodynamics of Continua, M. E. Gurtin, E. Fried and L. Anand, Cambridge University Press, 2010
4	Micromechanics of Defects in Solids, T. Mura, Martinus Nijhoff Publishers, 1987
5	Theory of Dislocations, P.M. Anderson, J.P. Hirth and J. Lothe, Cambridge University Press, 2017
6	Strengthening Mechanisms in Crystal Plasticity, A. Argon, Oxford University Press, 2007
7	Advanced Fracture Mechanics, M. F. Kanninen and C. H. Popelar, Oxford University Press, 1985