City University of Hong Kong
Course Syllabus

offered by Department of Materials Science and Engineering
with effect from Semester A 2021/22

Part I Course Overview

Course Title:	**Crystallography, Symmetry and Defects of Materials**
Course Code:	**MSE8013**
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

The course provides the fundamentals of crystallography, symmetry, diffraction and defects in materials, and explores the relationship between crystal symmetry and the directional properties of materials. Topics in this course include crystal structure, point groups, crystallographic restriction theorem, symmetry operations, and the use of symmetry in the tensor representation of crystal properties; Bragg's law, Fourier analysis, reciprocal lattice, Brillouin zones, diffraction conditions, Laue equations, x-ray, electron and neutron diffraction, and structure determination; point defects (lattice vacancies and colour centres), dislocations (Burger vectors, stress fields, grain boundaries, and dislocation density, multiplication and slip). The course will deepen the understanding on how the macroscopic behaviours of materials, including electronic, optical, magnetic and mechanical properties of materials, originate from fundamental crystallography, symmetry, and microstructure.

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.	Recognize the fundamentals of crystallography, crystal structure such as lattices and planes, crystal symmetry, point groups, and symmetry operations.			√	√
2.	Comprehend the relationship between crystal symmetry and physical properties such as electronic, optical and mechanical properties.		√	√	√
3.	Recognize the principles of Bragg's law, Fourier analysis, reciprocal lattice, Brillouin zone, structure factor, Ewald sphere, typical diffraction methods (X-ray, electron and neutron diffraction), and be able to relate them to the crystal structure determination.			√	√
4.	Learn about the fundamentals of point defects, and understand their effects in some important properties of crystals, such as electrical conductivity of semiconductors, optical absorption and emission properties of crystals with impurities or imperfections (colour centres)			√	√
5.	Recognize the theory of dislocations, including Burger vectors, stress fields, grain boundaries, and dislocation density, dislocation multiplication and slip, and interpret		√	√	√

	their relationship with mechanical properties of materials (strength and hardness) and crystal growth				
		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	Explain the fundamental concepts of crystallography, crystal structure, symmetry, symmetry operation, diffraction, point defects, dislocations, and the relationship between crystal symmetry, structure and physical properties.	√	√	√	√		2 hrs/wk
Tutorial	Discuss examples to substantiate the concepts studied in the lecture, and help students understand them.	√	√	√	√	√	0.5 hrs/wk

4. Assessment Tasks/Activities (ATs)

Assessment Tasks/Activities	CILO No.					Weighting*	Remarks
	1	2	3	4	5		
Continuous Assessment: 50%							
Assignments	√	√	√	√		30%	
Mid-term test	√	√	√			20%	
Examination: (duration: 2 hours)	√	√	√	√	√	50%	
						100%	

5. Assessment Rubrics

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B, B-)	Fair (C+, C, C-)	Marginal (D)	Failure (F)
1. Assignments	Ability to explain the basic concepts and their applications in understanding the physical properties of solids.	High	Significant	Moderate	Basic	Not even reaching the marginal leave
2. Midterm test	Capability on understanding the fundamentals of crystallography, crystal structure, symmetry operation, and diffraction.	High	Significant	Moderate	Basic	Not even reaching the marginal leave
3. Examination	Ability to understand the fundamental concepts and key applications of crystal symmetry, crystallography, crystal structure, diffraction, point defects, and dislocations, identify the relationship between crystal symmetry and structure defects and physical properties.	High	Significant	Moderate	Basic	Not even reaching the marginal leave

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

1. Keyword Syllabus

- Crystal structure;
- Periodic array of atoms: lattice translation vectors, basis and Bravais lattice, and primitive cell;
- Lattice systems and types: two- and three-dimensional;
- Index systems for lattice points, lattice directions, and crystal planes;
- Typical crystal structures: FCC, BCC, HCP, diamond and diamond-like structures,
- Symmetry in crystallography, and point groups;
- Crystallographic restriction theorem;
- Symmetry operations, and the use of symmetry in the tensor representation of crystal properties;
- Reciprocal space, reciprocal lattice, and Brillouin zone;
- Diffraction of waves by crystals: Bragg's law, Fourier transforms, diffraction conditions, Laue equations, structure factor, Ewald sphere;
- X-ray, electron and neutron diffraction, structure determination;
- Point defects: chemical impurities, lattice vacancies (Schottky and Frenkel), and interstitial defects;
- Colour centres in alkali halide crystals;
- Dislocations: Burger vectors, stress fields, grain boundaries, dislocation density, dislocation multiplication and slip;
- Relationship between dislocations and strength and hardness of materials;
- Dislocations and crystal growth;

2. Reading List
2.1 Compulsory Readings

1.	Nil

2.2 Additional Readings

1.	Charles Kittel, "Introduction to Solid State Physics", 8th Edition, John Wiley & Sons Inc. (QC176.K57, 1996/2005).
2.	Marc De Graef, Michael E. McHenry, "Structure of Materials: An Introduction to Crystallography, Diffraction and Symmetry", Cambridge University Press (QD911.D43 2012)
3.	Robert E. Newnham, "Properties of Materials: Anisotropy, Symmetry, Structure", Oxford University Press (QD931.N49 2005)
4.	N. W. Ashcroft and N. D. Mermin, "Solid State Physics", Saunders College Publishing (QC176.A83 1976)