MSE2109: BONDING AND STRUCTURE OF MATERIALS

Effective Term
Semester A 2025/26

Part I Course Overview

Course Title
Bonding and Structure of Materials

Subject Code
MSE - Materials Science and Engineering
Course Number
2109

Academic Unit
Materials Science and Engineering (MSE)

College/School
College of Engineering (EG)

Course Duration
One Semester

Credit Units
3

Level
B1, B2, B3, B4 - Bachelor's Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
Nil

Precursors
Nil

Equivalent Courses
Nil

Exclusive Courses
Nil

Part II Course Details

Abstract

This course will introduce concepts of atomic bonding and crystallography, as well as the relevant experimental methods for structure identification to students so that they can analyse structures of crystalline materials. Students can also understand the salient features of the correlation between crystal structures and their properties. Such knowledge can prepare students for the subsequent advanced courses on various properties of engineering materials.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Describe the types of bonding between different types of atoms		x		
2	Describe the types of crystal symmetry and crystal lattice types.		x	x	
3	Construct reciprocal lattice for a given crystal lattice in real space			x	
4	Analyse experimental diffraction data of crystals with simple lattice types.			x	

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.

Learning and Teaching Activities (LTAs)

	LTAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lecture	Students will engage in lectures to gain knowledge related to the key concepts in atomic bonding, crystal lattices and experimental diffraction methods	1, 2, 3, 4	3
2	Tutorial	Students will participate in tutorial activities to solve problems on geometry and symmetry of crystals, as well as the data analysis from diffraction experiments	2, 3, 4	1

3	Laboratory	Students will engage on laboratory activities related to diffraction experiments and the visualization of crystal lattice models	2, 4	3

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks ("-" for nil entry)	Allow Use of GenAI?
1	Tests	1, 2, 3, 4	20	There will be two 1-hour tests, each carries 10%	No
2	Lab reports	3, 4	15	Students need to complete a number of experiments that demonstrate the principles described and explained during lectures and tutorials	Yes
3	Assignments	1, 2, 3, 4	15	Take home assignments	Yes

Continuous Assessment (%)

50

Examination (%)

50

Examination Duration (Hours)

2

Minimum Examination Passing Requirement (%)

30

Additional Information for ATs

For a student to pass the course, at least 30% of the maximum mark for the examination must be obtained.

Assessment Rubrics (AR)

Assessment Task

1. Tests

Criterion

Able to solve numerical problems, and demonstrate the understanding of basic principles

Excellent (A+, A, A-)

Strong evidence of ability to solve advanced numerical problems; superior understanding of basic principles and extensive knowledge base

Good (B+, B, B-)

Evidence of ability to solve numerical problems; reasonable understanding of basic principles and familiarity with literature

Fair (C+, C, C-)

Student who is profiting from the university experience; can solve simple numerical problems; moderate understanding of basic principles

Marginal (D)

Sufficient familiarity with the subject matter to enable the student to progress without repeating the course

Failure (F)

Little evidence of familiarity with the subject matter; weak ability to solve numerical problems; limited, or irrelevant use of basic principles and literature

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Assessment Task

2. Lab reports

Criterion

Ability to explain the methodology and results from experiments

Excellent (A+, A, A-)

Strong evidence of ability to explain the methodology and results from experiments; superior understanding of basic principles and extensive knowledge base

Good (B+, B, B-)

Evidence of ability to explain the methodology and results from experiments; reasonable understanding of basic principles and familiarity with literature

Fair (C+, C, C-)

Student who is profiting from the university experience; can explain the basic methodology and results from experiments; moderate understanding of basic principles

Marginal (D)

Sufficient familiarity with the experimental methodology or significance of the experiments to progress without repeating the course

Failure (F)

Little evidence of familiarity with the experimental methodology and limited or irrelevant understanding of the results or significance of the experiments

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Assessment Task

3. Assignments

Criterion

Able to solve numerical problems, and demonstrate the understanding of basic principles

Excellent (A+, A, A-)

Strong evidence of ability to solve advanced numerical problems; superior understanding of basic principles and extensive knowledge base

Good (B+, B, B-)

Evidence of ability to solve numerical problems; reasonable understanding of basic principles and familiarity with literature

Fair (C+, C, C-)

Student who is profiting from the university experience; can solve simple numerical problems; moderate understanding of basic principles

Marginal (D)

Sufficient familiarity with the subject matter to enable the student to progress without repeating the course

Failure (F)

Little evidence of familiarity with the subject matter; weak ability to solve numerical problems; limited, or irrelevant use of basic principles and literature

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Assessment Task

4. Examination

Criterion

Able to solve numerical problems, and demonstrate the understanding of basic principles

Excellent (A+, A, A-)

Strong evidence of ability to solve advanced numerical problems; superior understanding of basic principles and extensive knowledge base

Good (B+, B, B-)

Evidence of ability to solve numerical problems; reasonable understanding of basic principles and familiarity with literature

Fair (C+, C, C-)

Student who is profiting from the university experience; can solve simple numerical problems; moderate understanding of basic principles

Marginal (D)

Sufficient familiarity with the subject matter to enable the student to progress without repeating the course

Failure (F)

Little evidence of familiarity with the subject matter; weak ability to solve numerical problems; limited, or irrelevant use of basic principles and literature

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Part III Other Information

Keyword Syllabus

- Atomic bonding: covalent, ionic and metallic bonding; hydrogen bond, van der Waal’ s force (2 hours)
- Crystalline vs. amorphous states (2 hours)
  Periodicity, long-range or short-range order, quasicrystals
- Crystal lattice (6 hours)
  Symmetry of crystals, Laue groups, Bravais lattices
- Crystal planes and Miller indices (4 hours)
- Reciprocal lattice (4 hours)
  Representation of crystal lattice in reciprocal space
- Diffraction of radiation by crystal lattice (4 hours)
  Bragg’ s law, Fourier transform and structure factor
- Experimental diffraction methods (4 hours)

X-ray diffraction methods, Laue method, Ewald’ s sphere construction, x-ray diffractometer, x-ray source and detectors, powder diffraction, single crystal diffraction, neutron diffraction

Reading List

Compulsory Readings

	Title
1	X-Ray Diffraction Crystallography, Waseda, Yoshio, Matsubara, Eiichiro, Shinoda, Kozo, 2011, Springer
2	William D. Callister, Jr., Materials Science and Engineering, An Introduction, John Wiley & Sons, Inc.
3	Frank Hoffmann, Introduction to Crystallography, Springer Nature (eBook)

Additional Readings

	Title
1	Elements of X-ray Diffraction, 2nd ed., B. D. Cullity, 1978, Addison-Wesley.
2	X-Ray Diffraction, C. Suryanarayana, M. Grant Norton, Springer-Verlag US 1998
3	Keh Yung Cheng, III–V Compound Semiconductors and Devices -An Introduction to Fundamentals, Springer