MSE8020: STRUCTURAL PROPERTIES OF MATERIALS

Effective Term
Semester A 2025/26

Part I Course Overview

Course Title
Structural Properties of Materials

Subject Code
MSE - Materials Science and Engineering

Course Number
8020

Academic Unit
Materials Science and Engineering (MSE)

College/School
College of Engineering (EG)

Course Duration
One Semester

Credit Units
3

Level
R8 - Research 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 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.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Describe physical quantities and formulate physical principles using vector/tensor notations, algebra, and analysis.	10		x	
2	Analyse the structure of crystalline materials by examining close packing, coordination polyhedra, and symmetry operations (point group, plane group and space group).	20		x	x
3	Derive the constraints on material properties by analysing material structure, bonding character, and the fundamental principles of physics.	20	x	x	
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	x	x	x
5	Evaluate the strengthening effect based on the mechanisms that involve the interaction between different defects.	20		x	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 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.	1, 2, 3, 4, 5	2
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, 2, 3, 4, 5	1

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks ("-" for nil entry)	Allow Use of GenAI?
1	Homework	1, 2, 3, 4, 5	30	-	Yes
2	Midterm	1, 2, 3, 4	20	-	No

Continuous Assessment (%)

50

Examination (%)

50

Examination Duration (Hours)

2

Assessment Rubrics (AR)

Assessment Task

Homework (applicable to students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

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.

Excellent

(A+, A, A-) High

Good

(B+, B, B-) Significant

Fair
(C+, C, C-) Moderate

Marginal
(D) Basic

Failure
(F) Not even reaching the marginal levels

Assessment Task
Midterm (applicable to students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion
Students can explain the basic concepts and perform quantitative analysis of material structure and elastic problems.

Excellent
(A+, A, A-) High

Good
(B+, B, B-) Significant

Fair
(C+, C, C-) Moderate

Marginal
(D) Basic

Failure
(F) Not even reaching the marginal levels

Assessment Task
Examination (applicable to students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion
Students can explain plastic behaviour of materials based on the structure and dynamics of defects, perform quantitative analysis on strengthening and fracture of materials.

Excellent
(A+, A, A-) High

Good
(B+, B, B-) Significant

Fair
(C+, C, C-) Moderate

Marginal
(D) Basic

Failure
(F) Not even reaching the marginal levels

Assessment Task

Homework (applicable to students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

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.

Excellent

(A+, A, A-) High

Good

(B+, B) Moderate

Marginal

(B-, C+, C) Basic

Failure

(F) Not even reaching the marginal levels

Assessment Task

Midterm (applicable to students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

Students can explain the basic concepts and perform quantitative analysis of material structure and elastic problems.

Excellent

(A+, A, A-) High

Good

(B+, B) Moderate

Marginal

(B-, C+, C) Basic

Failure

(F) Not even reaching the marginal levels

Assessment Task

Examination (applicable to students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

Students can explain plastic behaviour of materials based on the structure and dynamics of defects, perform quantitative analysis on strengthening and fracture of materials.

Excellent

(A+, A, A-) High

Good

(B+, B) Moderate

Marginal

(B-, C+, C) Basic

Failure

(F) Not even reaching the marginal levels

Part III Other Information

Keyword Syllabus

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

Reading List

Compulsory Readings

	Title
1	Lecture notes
2	Tutorial questions
3	Selected journal articles

Additional Readings

	Title
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