MSE8021: KINETIC AND THERMODYNAMIC PROPERTIES OF MATERIALS

Effective Term
Semester A 2025/26

Part I Course Overview

Course Title
Kinetic and Thermodynamic Properties of Materials

Subject Code
MSE - Materials Science and Engineering
Course Number
8021

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

The course aims to provide graduate students a solid foundation of thermodynamics and kinetics of materials. It emphasizes fundamental theory and quantitative analysis. The thermodynamics section includes classical laws of thermodynamics, their statistical perspectives, single and multi-component systems, thermodynamics of phase diagram, multiphase and reacting systems, and thermodynamic of defects. The kinetics section covers motion of point, line, and interface defects. The course will also introduce general features of phase transformation, nucleation and growth theory, and martensitic transformation. Upon successful completion of the course, students will be equipped with sufficient knowledge to (i) derive quantitative relations among different material properties and variables, and (ii) analyse a wide range of processes during changes in material compositions, phases and microstructures.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Analyse and calculate thermodynamic material properties and process variables using the laws of thermodynamics and equilibrium criteria.			x	
2	Apply basic statistical mechanics and describe relations between microscopic and macroscopic thermodynamic properties.		x	x	
3	Derive and calculate thermodynamic properties in single and multicomponent materials using statistical mechanics, macroscopic properties and phase diagrams.		x	x	
4	Describe and analyse thermodynamics and kinetics of point, line and interface defects.			x	x
5	Describe and analyse thermodynamics, kinetics and physical mechanisms of phase transformations.			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 acquire key concepts and theories about the laws of thermodynamic, thermodynamic relationships, single component and multi-component phase equilibria as well as statistical thermodynamics, phase diagram, thermodynamics and kinetics of defects and phase transformation.	1, 2, 3, 4, 5	2
2	Tutorial	Students will enhance their mastery of theory and participate in practical problem-solving processes.	1, 2, 3, 4, 5	1

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks ("-" for nil entry)	Allow Use of GenAI?
1	Midterm	1, 2, 3	20	There will be one midterm test	No
2	Assignment	1, 2, 3, 4, 5	20	Take-home assignments	No

Continuous Assessment (%)

40

Examination (%)

60

Examination Duration (Hours)

2

Assessment Rubrics (AR)

Assessment Task

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

Criterion

Be able to derive thermodynamic property relations and solve quantitative problems, and demonstrate the understanding of basic thermodynamics and statistical mechanics principles.

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 level

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

Criterion
Be able to derive thermodynamic property relations and calculate material thermodynamic properties, and apply theory to solve practical 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 level

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

Criterion
Be able to derive thermodynamic property relations and calculate quantitative material properties, and demonstrate the understanding of thermodynamic and kinetic theories and apply them in practical 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 level

Assessment Task

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

Criterion

Be able to derive thermodynamic property relations and solve quantitative problems, and demonstrate the understanding of basic thermodynamics and statistical mechanics principles.

Excellent

(A+, A, A-) High

Good

(B+, B) Moderate

Marginal

(B-, C+, C) Basic

Failure

(F) Not even reaching the marginal level

Assessment Task

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

Criterion

Be able to derive thermodynamic property relations and calculate material thermodynamic properties, and apply theory to solve practical problems.

Excellent

(A+, A, A-) High

Good

(B+, B) Moderate

Marginal

(B-, C+, C) Basic

Failure

(F) Not even reaching the marginal level

Assessment Task

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

Criterion

Be able to derive thermodynamic property relations and calculate quantitative material properties, and demonstrate the understanding of thermodynamic and kinetic theories and apply them in practical problems.

Excellent

(A+, A, A-) High

Good

(B+, B) Moderate

Marginal

(B-, C+, C) Basic

Failure

(F) Not even reaching the marginal level

Part III Other Information

Keyword Syllabus

- The structure and laws of thermodynamics
- Thermodynamic variables and relationships
- Thermodynamic equilibrium criteria and equilibrium conditions
- Basics of statistical mechanics
- Single component systems
- Multicomponent system: solution and heterogeneous materials
- Thermodynamics of phase diagram, phase diagram
- Multicomponent, multiphase, reacting systems
- Driving force, equation and solution of diffusion processes
- Motion of dislocation, surface and interface
- Homogeneous and heterogeneous nucleation and growth
- Diffusionless phase transformation, massive transformation and martensitic transformation

Reading List

Compulsory Readings

	Title
1	Lecture notes
2	Tutorial problems and solutions

Additional Readings

	Title
1	Robert T DeHoff, "Thermodynamics in Materials Science", New York, McGraw-Hill, 1993.
2	Kinetics of Materials, RW Balluffi, SM Allen, WC Carter, Wiley & Sons, New Jersey.
3	Phase Transformations in Metals and Alloys, DA Potter, KE Easterling, Chapman and Hall.
4	The Theory of Transformations in Metals and Alloys, JW Christian, Pergamon Press, Oxford.
5	DV Ragone Thermodynamics of Materials, Vols. 1 and 2, John Wiley and Sons, NY, 1995.