MSE3195: KINETICS AND PHASE TRANSFORMATIONS

Effective Term
Semester A 2025/26

Part I Course Overview

Course Title
Kinetics and Phase Transformations

Subject Code
MSE - Materials Science and Engineering
Course Number
3195

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
MSE3190 Thermodynamics of Materials

Precursors
MSE2102 Introduction to Materials Engineering

Equivalent Courses
MSE3109 Kinetics and Phase Transformations

Exclusive Courses
Nil

Part II Course Details

Abstract

The course aims at covering the basic principles and processes pertinent to the kinetic aspects of structural changes in engineering materials. Students will gain the key knowledge in development of microstructures, and hence the properties, in materials as a result of thermo- mechanical treatments. Upon successful completion of the course, students are expected to be equipped with scientific and engineering knowledge to perform qualitative and quantitative analyses of transformation kinetics of simple structural changes. They will also be able to design and apply simple thermo-mechanical treatment routes to conventional engineering alloys to achieve desirable properties.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Describe the thermodynamics of solid solutions and construct binary phase diagrams.		x	x	
2	Analyze quantitatively the diffusion processes in solids and the migration of interfaces.		x	x	
3	Explain the nucleation and growth processes of phase transformation as well as spinodal decomposition.			x	x
4	Analyze quantitatively phase transformation kinetics using the Johnson-Mehl Equation.		x		
5	Explain and apply the nucleation and growth processes to the heat treatments of steel and aluminum alloys.		x	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	Lectures	Students will engage in lecture activities covering key concepts, such as thermodynamic equilibrium, diffusion, classification and governing kinetics in phase transformation	1, 2, 3, 4, 5	2 hrs 50 min/week

2	Tutorials	Students will critically engage in interactive discussion and learning to apply basic principles to difficult homework and quiz problems	1, 2, 3, 4, 5	1 hr/week
3	Lab Work	Students will have a hand- on experience in diffusion measurement in alloys and aging-hardenable aluminum alloys. Students are required to organize the lab results into a logic and concise report	3, 4, 5	0.5hr/week

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks ("-" for nil entry)	Allow Use of GenAI?
1	Homework, quizzes	1, 2, 3, 4, 5	20	-	No
2	Mid-term test	1, 2, 3, 4, 5	15	-	No
3	Lab reports	3, 4, 5	15	-	No

Continuous Assessment (%)

50

Examination (%)

50

Examination Duration (Hours)

2

Minimum Continuous Assessment Passing Requirement (%)

50

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. Examination

Criterion

Ability to describe and explain the scientific principles and to solve physics and engineering problems

Excellent (A+, A, A-)

High

Good (B+, B, B-)

Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Assessment Task
2. Lab report

Criterion
Ability to explain the methodology and to analyse the data

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Assessment Task
3. Mid-term test

Criterion
Ability to explain scientific principles and to solve related problems

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Assessment Task

4. Homework Assignment

Criterion

Ability to explain and apply the fundamental principles of kinetics and phase transformation to practical phenomenon in metals and alloy

Excellent (A+, A, A-)

High

Good (B+, B, B-)

Significant

Fair (C+, C, C-)

Moderate

Marginal (D)

Basic

Failure (F)

Not even reaching marginal levels

Part III Other Information

Keyword Syllabus

- Thermodynamics of Phase Diagrams (4 hours)
  - Gibbs free energy of solid solutions and its relationship with binary phase diagrams
- Surface/interface properties and phenomena (2 hours)
  - Surface energy of solids, grain boundaries, interphase interfaces, impurity segregation at interface.
- Diffusion in solids (4 hours)
  - Fick’ s laws, interdiffusion, high diffusivity paths.
- Nucleation and growth of phase transformation (4 hours)
  - Nucleation and growth. Gibbs-Thompson effect. Precipitation coarsening.
- Spinodal decomposition (1 hour)
  - Miscibility gap and spinodal curve, phase separation kinetics, microstructure resulting from spinodal decomposition.
- Transformation kinetics (1 hour)
  - Arrhenius equation, Johnson-Mehl equation.
- Heat-treatment of carbon steel (5 hours)
  - Fe-C system, eutectoid transformation, bainitic transformation, martensitic transformation, hardening and tempering.
- Precipitation hardening of aluminum alloys (5 hours)
  - GP-zones, Formation of intermediate phases, Oswald ripening.

Reading List

Compulsory Readings

	Title
1	Phase Transformations in Metals and Alloys”, D A Porter and K E Easterling, 2nd ed., Chapman and Hall, 1992

Additional Readings

	Title
1	“Physical Metallurgy Principles”, R E Reed-Hill, R Abbaschian, 3rd ed., PWS-Kent, 1992.
2	“Stability of Microstructure in Metallic Systems”, J W Martin, R D Doherty and B Cantor, 2nd ed., Cambridge University Press, 1997.