MSE3190: THERMODYNAMICS OF MATERIALS

Effective Term
Semester A 2025/26

Part I Course Overview

Course Title
Thermodynamics of Materials

Subject Code
MSE - Materials Science and Engineering

Course Number
3190

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
PHY1201, PHY1202, MA1200/MA1300, MA1201/MA1301, MSE2102

Precursors
Nil

Equivalent Courses
AP3190 Thermodynamics of Materials

Exclusive Courses
PHY3290 Thermodynamics

Part II Course Details

Abstract
This course aims to introduce thermodynamics of materials and its applications in materials science and engineering. It covers laws of thermodynamics, thermodynamic variables and relationships, phase equilibria, behavior and properties of

ideal gases, solutions, phase diagrams, single and multicomponent multiphase heterogeneous systems. Upon successful completion of the course, students will be able to perform both qualitative and quantitative analyses on materials properties, relationships, phase equilibria, phase diagrams and phase properties across a wide range of material systems and thermodynamic processes.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Describe thermodynamic concepts, variables, relationships and laws of thermodynamics.			x	
2	Apply the laws of thermodynamics and relationships to derive and calculate thermodynamic material properties including system heat, work, entropy, enthalpy and free energy, etc., and analyze thermodynamic cycles.			x	
3	Describe and analyze thermodynamic equilibrium criteria and conditions under various constraints.			x	
4	Describe and analyze single and multi-component systems, phase diagrams, phase rules and phase equilibria.			x	
5	Analyze and calculate properties of mixings, solutions, other structures, material models and phases.			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 and Tutorial	Students will engage in formal lectures to acquire and discuss key concepts, definitions, derivations and applications of thermodynamic variables, relations, laws, material models, mixing processes, phase diagrams and phase transformations.	1, 2, 3, 4, 5	3 hours/week

2	Tutorial	Student will participate in practical problem solving and calculations to enhance their mastery of thermodynamic knowledge.	1, 2, 3, 4, 5	1 hour/ week
3	Laboratory	Student will perform and participate in practical experiments and apply thermodynamics to analyze experimental results and calculate material properties.	2, 3, 4, 5	1 hour/ week

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks ("-" for nil entry)	Allow Use of GenAI?
1	Midterm	1, 2, 3	15	There will be one midterm.	No
2	Lab reports	1, 2, 3, 4, 5	10	Students will complete a number of experiments and apply thermodynamics to analyze, calculate and discuss experimental results.	No
3	Assignments	1, 2, 3, 4, 5	15	Take-home or in-class assignments.	No

Continuous Assessment (%)

40

Examination (%)

60

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. Midterm

Criterion

Be able to derive thermodynamic property relationships and calculate thermodynamic properties, and demonstrate understandings of key thermodynamics concepts and basic 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
2. Lab reports

Criterion
Be able to describe experimental details and critical procedures, as well as to analyze, calculate and discuss key experimental results and insights.

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
3. Assignment

Criterion
Be able to derive thermodynamic property relationships, calculate thermodynamic properties, analyze phase diagrams, phase rules, describe equilibrium conditions and material models, and demonstrate understandings of key thermodynamics concepts and apply basic 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
4. Examination

Criterion
Be able to derive thermodynamic property relationships, calculate thermodynamic properties, analyze phase diagrams, phase rules, describe equilibrium conditions and material models, and demonstrate understandings of key thermodynamics concepts and apply basic 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

Part III Other Information

Keyword Syllabus

- Introduction
  - Thermodynamic system and environment, state and process variables, state functions, thermodynamic cycles, reversible and irreversible processes, thermodynamic temperature and properties
- Structure and laws of thermodynamics
  - Heat, internal energy, conservation of energy, entropy as a state function and microscopic view of entropy, entropy production and reversibility, heat engines and efficiency, heat pump and coefficient of performance
- Thermodynamic variables and relations
  - Enthalpy, entropy, free energy, thermodynamic potentials, experimental variables, coefficient and Maxwell relationships, derivations of thermodynamic relations
- Thermodynamic equilibrium
  - Variations of Gibbs free energy with temperature and pressure, chemical potentials and free energy surfaces, phase equilibria, criteria and conditions of equilibrium
- Unary heterogeneous systems

  - Phase equilibrium and phase change, heat of fusion, melting and vaporization, Clausius-Clapeyron equation, vapor pressure, vapor-condensed phase equilibria, solid-solid phase equilibria
- Multicomponent systems: gases and solutions
  - Mole fraction, ideal gases, partial molar properties, chemical potentials, equilibrium, Gibbs-Duhem equation, enthalpy, entropy and free energy of mixing, ideal and nonideal solutions, activity
- Phase diagrams and phase rules
  - Phases, phase diagram of single and multicomponent systems, Gibbs phase rules, Gibbs free energy vs composition, standard states, phase diagram of binary and high order systems

Reading List

Compulsory Readings

	Title
1	Lecture slides (will be distributed during the lecture sessions)
2	Tutorial samples with key problem-solving steps

Additional Readings

	Title
1	David R. Gaskell and David E. Laughlin, "Introduction to the Thermodynamics of Materials", 6th ed. CRC Press, Taylor & Francis Group
2	David V Ragone, "Thermodynamics of Materials", New York, Wiley, 1995. (call no.: TA418.52.R34 1995, v.1 and 2).
3	Yunus A Çengel, Michael A Boles, "Thermodynamics – An Engineering Approach", 6th ed. in SI units, McGraw-Hill, 2008. (Call no.: TJ265 C43 2008; ISBN 007-125084-0).
4	Robert T DeHoff, "Thermodynamics in Materials Science", New York, McGraw-Hill, 1993. (call no.: TA403.6.D44 1993).
5	D A Porter and K E Easterling, "Phase Transformations in Metals and Alloys", 2nd ed., CRC Press, 2001.