MSE3190: THERMODYNAMICS OF MATERIALS

Effective Term
Semester B 2023/24

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
Nil

Precursors
Nil

Equivalent Courses
AP3190 Thermodynamics of Materials

Exclusive Courses
PHY3290 Thermodynamics

Part II Course Details

Abstract
The course aims at covering the basic principles of thermodynamics and the applications of those principles in engineering practice and in materials science. Upon successful completion of the course, students are expected to be equipped with

sufficient knowledge to analyse simple thermodynamic cycles as well as to describe and to determine the equilibrium states of a material.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Analyze quantitatively the conversions among heat, work and energy in different processes using the 1st Law of Thermodynamics.			x	
2	Describe the concepts of irreversible processes in terms of entropy generation and the 2nd Law of Thermodynamics.			x	
3	Describe and analyze quantitatively the operating principles of heat engines and heat pumps, including the idealized devices based on Carnot cycle.			x	
4	Explain the features in binary phase diagrams based on the 'Conditions for Equilibrium' and the thermodynamics of mixing.			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.

Teaching and Learning Activities (TLAs)

	TLAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lecture and Tutorial	Explain and discuss the key concepts about laws of thermodynamic, thermodynamic relationships, single component and multi-component phase equilibria	1, 2, 3, 4	3 hours/week
2	Laboratory	To demonstrate all the ley concepts learned in the lecture and tutorial sessions by experimentation	1, 2, 3, 4	1 hour/ week

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Test	1, 2, 3, 4	20	There will be one mid-term test
2	Lab reports	1, 2, 3, 4	15	Students need to complete a number of experiments that demonstrate the principles discussed in lectures/tutorials
3	Assignment	1, 2, 3, 4	5	Take-home or in-classassignments

Continuous Assessment (%)
40

Examination (%)
60

Examination Duration (Hours)
2

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. Test

Criterion
Able to solvenumerical problems,and demonstrate theunderstanding ofbasic 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
Ability to explain themethodology andresults fromexperiments

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
Able to solvenumerical problems,and demonstrate theunderstanding ofbasic 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
Able to solvenumerical problems,and demonstrate theunderstanding ofbasic 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
  Systems and surroundings, state functions, process variables, extensive and intensive properties.
- The 1st laws of thermodynamics (4 hours)
  Internal energy, heat, work, the closed and open systems, temperature and Zeroth law of thermodynamics, enthalpy, steady state, heat capacities, the 1st law of thermodynamics, kinetic theory of gas, ideal gas.
- The 2nd law of thermodynamics and heat engines (4 hours)
  2nd law of thermodynamics, entropy, reversible and irreversible processes, Carnot cycle, heat engines and efficiency, heat pump and coefficient of performance, statistical view of entropy.
- Thermodynamic Variables and Property relationships (2 hours)
  Free energies, chemical potentials, heat capacities, coefficient of thermal expansion, compressibility, coefficient relations, Maxwell relations.
- Equilibrium (6 hours)
  Equilibrium state vs. steady state, Criterion for equilibrium, Conditions for equilibrium, phase equilibrium in a unary two-phase system.
- Phase rule and phase diagrams (10 hours)
  Phases, components, equilibrium conditions, Gibbs phase rule, unary system, The Clausius-Clapeyron equation, solid solutions, entropy of mixing, ideal solution, regular solution, equilibrium in multi-component heterogeneous system, binary phase diagrams.

Reading List

Compulsory Readings

	Title
1	Lecture slides (will be distributed during the lecture sessions)
2	Tutorial slides (will be distributed during the tutorial sessions)

Additional Readings

	Title
1	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).
2	David V Ragone, “Thermodynamics of Materials”, New York, Wiley, 1995. (call no.: TA418.52.R34 1995, v.1 and 2).
3	Robert T DeHoff, “Thermodynamics in Materials Science”, New York, McGraw-Hill, 1993. (call no.: TA403.6.D44 1993).
4	D A Porter and K E Easterling, “Phase Transformations in Metals and Alloys”, 2nd ed., CRC Press, 2001.