

# MSE5304: THERMODYNAMICS OF MATERIALS

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## Effective Term

Semester A 2025/26

## Part I Course Overview

### Course Title

Thermodynamics of Materials

### Subject Code

MSE - Materials Science and Engineering

### Course Number

5304

### Academic Unit

Materials Science and Engineering (MSE)

### College/School

College of Engineering (EG)

### Course Duration

One Semester

### Credit Units

3

### Level

P5, P6 - Postgraduate 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 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 DEC-A1 DEC-A2 DEC-A3 app.)		
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 apply the mass and energy balances to reacting systems and describe conditions for chemical equilibrium.			x
5	Identify major applications of thermodynamics of materials and design creative solutions for different applications			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	1	Large Class Activities (Lecture/Tutorial)	1, 2, 3, 4, 5	3 hrs/week
2	2	Experiment/video demonstration	1, 2, 3, 4, 5	0.5 hr/week

### Assessment Tasks / Activities (ATs)

ATs	CILO No.	Weighting (%)	Remarks ("- for nil entry)	Allow Use of GenAI?	
1	Assignment	1, 2, 3, 4, 5	5	Take-home or in-class assignments	Yes
2	Mid-term test	1, 2, 3, 4, 5	20	-	No

3	Report/Essay	1, 2, 3, 4, 5	15	Students will engage in writing reports/essays for experiment/video demonstrations, or analysis of original research publications to generate work with new concepts	Yes
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**Continuous Assessment (%)**

40

**Examination (%)**

60

**Examination Duration (Hours)**

2

**Assessment Rubrics (AR)****Assessment Task**

Examination (for students admitted before Semester A 2022/23 and in Semester A 2024/25 &amp; thereafter)

**Criterion**

Able to solve numerical problems, and demonstrate the understanding of 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 marginal levels

**Assessment Task**

Report/essay (for students admitted before Semester A 2022/23 and in Semester A 2024/25 &amp; thereafter)

**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

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**Assessment Task**

Mid-term test (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

**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

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**Assessment Task**

Assignment (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

**Criterion**

Ability to sum up, to assess, and to comment on the work of their peers

**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

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**Assessment Task**

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

**Criterion**

Able to solve numerical problems, and demonstrate the understanding of basic principles

**Excellent**

(A+, A, A-) High

**Good**

(B+, B) Moderate

**Marginal**

(B-, C+, C) Basic

**Failure**

(F) Not even reaching marginal levels

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**Assessment Task**

Report/essay (for students admitted from Semester A 2022/23 to Summer Term 2024)

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## Part III Other Information

### Keyword Syllabus

- Introduction

Systems and surroundings, state functions, process variables, extensive and intensive properties.

- The 1st laws of thermodynamics

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

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

Free energies, chemical potentials, heat capacities, coefficient of thermal expansion, compressibility, coefficient relations, Maxwell relations.

- Equilibrium

Equilibrium state vs. steady state, Criterion for equilibrium, Conditions for equilibrium, phase equilibrium in a unary two-phase system.

- Phase rule and phase diagrams

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.

- Chemical reactions

Chemical internal energy, Combustion reaction, Chemical equilibrium

### Reading List

#### Compulsory Readings

Title	
1	Nil

#### Additional Readings

<b>Title</b>	
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., CRCPress 2001.
5	D.R. Gaskell, "Introduction to the Thermodynamics of Materials"