BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE-PILANI- HYDERABAD CAMPUS

SECOND SEMESTER 2022-2023

**(COURSE HANDOUT PART II)**

Date: 13/03/2023

In addition to part-I (general handout for all courses in the time-table), this handout provides the specific details regarding the course.

Course No.: **BITS F111**

Course Title: **Thermodynamics**

Instructor-in-charge: **Vikranth Kumar Surasani**

Instructors: Ramesh Babu A, Karthik Chetan, R. Parameshwaran, Jeeva Jaidi, Santanu Prasad Datta, KRC Murthy, Arnab Dutta, Debirupa Mitra, Ramendra Pal, Jayaprakash K S

**1. Course Description**: Concepts and laws of thermodynamics, macroscopic thermodynamic properties, application to closed and open systems, microscopic approach to entropy, equations of state, thermodynamics of non-reacting mixtures.

**2. Scope and Objective:** Thermodynamics deals with energy, matter, and the laws governing their interactions. It is essential to learn its usefulness in the design of processes, devices, and systems involving effective utilization of energy and matter. The course emphasizes on the fundamentals and concepts of the laws of thermodynamics as applied to control mass and control volume systems. Irreversibility and availability are powerful tools in the design of thermodynamic systems.

**3. Learning Outcomes:**

* Understand the fundamentals of thermodynamic systems, processes and cycles, and concepts related to pressure, energy, force, and temperature
* Solve problems related to pure substances using thermodynamic tables
* Apply the first law of thermodynamics to solve problems involving different forms of energy, including heat and work for control mass and control volume systems
* Understand the need for the second law of thermodynamics and its application to control mass and control volume systems
* Solve problems using the first and second laws of thermodynamics
* Understand the basic principles of entropy, irreversibility and availability

**4. Text Book**:

**T1** Claus Borgnakke & Richard E. Sonntag, “Fundamentals of Thermodynamics”, John Wiley& Sons, 2019, 10thEdition, An Indian Adaption.

**T2** Adopted from book by Van Wylen & others “Thermodynamics Tables, Figures and Charts”, Notes-EDD, 2007.

**5. Reference book:**

* Yunus A Cengel; Michael A Boles ., “Thermodynamics: An Engineering Approach”, McGraw-Hill, 2015, 8th Edition

**6. Course Plan**:

| **Topic** | **Lecture Nos.** | **Learning Objectives** | **Topics to be covered** | **Chapter in the Text Book** |
| --- | --- | --- | --- | --- |
| Introduction& Preliminaries | 1-2 | Understand basic concepts and definitions involved in thermodynamics | Introduction, thermodynamic systems, properties & state, process & cycle | T1: 1.1-1.4 |
| Force, Energy, Pressure, Specific Volume, Zeroth law, Temperature scales. | T1: 1.5-1.4 |
| Properties of Pure Substance | 3-4 | Understand the properties of pure substances | Phase equilibrium, independent properties, equations of state, compressibility factor. | T1: 2.1 - 2.3,  T1: 2.5 - 2.9 |
| 5-7 | Use thermodynamic tables to obtain properties of pure substances | Tables of thermodynamic properties & their use. | T2-2.4 |
| Energy Equation and First law of Thermodynamics | 8-10 | Solve problems related to boundary work | Definition of work and its identification, work done at the moving boundary. | T1:3.3 – 3.4,  T1:3.14 |
| 11-12 | Differentiate between work and heat | Concept of heat, comparison of heat and work. | T1:3.5 – 3.6 |
| 13-14 | Understand the first law of thermodynamics for a control mass and the various forms of energy involved | First law for a cycle as well as for a change of state; internal energy & enthalpy; specific heats, internal energy, enthalpy & specific heat of ideal gases. | T1:3.1 - 3.3,  T1:3.7,  T1:3.9 -3.11 |
| 15-17 | Apply the first law to solve problems for a control mass | Non uniform distribution of states and masses, Transient process; | T1:3.12, 3.13 |
| Energy Analysis for Control Volume | 18-20 | Differentiate between control mass and control volume.  Understand the first law of thermodynamics for a control volume | Conservation of mass in control volume; first law for control volume; Steady State process; examples of Steady State processes, transient processes. | T1:4.1 – 4.4,  T1:4.6 |
| 21-22 | Apply the first law to solve problems for a control volume | Problem analysis & solution technique; examples. | T1:4.1 – 4.7 |
| The Second Law of Thermodynamics | 23-27 | Understand the need for Second Law of Thermodynamics and its basic concepts | heat engine, heat pump, refrigerator;  Limitations of first law & need for the second law; reversible process; Factors that render irreversibility | T1:5.1 – 5.4 |
| Carnot cycle; energy-conversion efficiency and COP, Kelvin-Planck & Clausius statements, the thermodynamic temperature scale. | T1:5.5-5.7 |
| The ideal gas Carnot cycle, Ideal Vs Real machines; The Inequality of Clausis and Engineering applications | T1:5.8-5.11 |
| Entropy | 28-34 | Understand the physical principles behind entropy and formulation of second law for control mass | Concept of entropy; the need and definition of entropy; entropy of a pure substance; Entropy change of a reversible & irreversible processes; | T1:6.1 - 6.3 |
| Thermodynamic property relation; Entropy change of solid or liquid; Entropy change of gas  The reversible polytrophic Process for ideal gas | T1:6.4-6.7 |
| Entropy Change in of Control Mass & Entropy Balance Equation for a Closed System; The principle of increase in Entropy and Balance equation in rate form. | T1:6.8-6.11 |

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| Entropy Analysis for Control Volume | 35-37 | Understand the formulation of second law for control volume | Second law for control volume; S.S. &transient processes; reversible S.S.S.F. process; principle of increase of entropy | T1:7.1– 7.4 |
| 38-40 | Apply the second law of thermodynamics to solve problems for a control volume | Understanding efficiency and related problems; problem analysis & solution technique. | T1:7.5 |
| Exergy | 41-43 | Understand the physical principles behind Irreversibility and availability | Available energy, reversible work & irreversibility for control mass and control volume processes; second law efficiency. | T1:8.1 – 8.4 |

**7. Evaluation Scheme**:

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| --- | --- | --- | --- | --- |
| Evaluation Component | **Duration** | **Weightage (%)** | **Date &Time** | **Nature of Component** |
| Mid semester Test$ | 90 min | 25% | 03/05  9.30 - 11.00AM | CB |
| Tutorial Tests | 40 min | 15% |  | OB |
| Quizzes | 40 min | 15% |  | CB |
| Comprehensive Exam$ | 180 min | 45% | 08/07 FN | CB(15%)+OB(30%) |

$EDD Notes on “Thermodynamics Tables, Figures and Charts” is allowed in the closed book tests also. However, it should not be defaced by writing formula, equations, etc.

8. **Chamber Consultation Hour:** To be announced by the respective instructors.

9. **Notices:** All notices concerning this course shall be displayed on the CMS (the Institute’s web based course management system). Besides this, students are advised to visit regularly CMS for latest updates.

10. **Make-up Policy:** Make-up for the mid and comprehensive tests shall be granted only for genuine cases. Requests for the make-up tests, duly forwarded by the respective tutorial section instructors, should reach the IC well before the tests. **For cases related to illness, proper documentary evidence is essential.**

11. **Academic Honesty and Integrity Policy:** Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

**Instructor in-Charge**

**BITS F111**