Course Type	Course Code	Name of Course	L	T	P	Credit
DC	NMEC515	Advanced Thermodynamics	3	1	0	4

Course Objective

Prerequisite: Basic knowledge in thermodynamics is essential

- To make the students conversant with the fundamentals of thermodynamics and to apply the principles to various thermal systems.
- Novelty: Advanced topics like Exergy analysis of reactive systems and introduction to irreversible thermodynamics are introduced.

Learning Outcomes

Upon successful completion of this course, students will:

- have a broad understanding of basic concepts of thermodynamics.
- have a thorough understanding of entropy and be able to estimate rate of entropy generation in different thermal systems
- undergoing actual processes.
- be able to apply exergy analysis to both reactive and non reactive systems undergoing thermodynamic cycles or processes and estimate the associated reversible work and irreversibility.
- be able to apply the thermodynamic property relations to calculate various thermodynamic properties using the measured properties.
- understand the theory and concept of thermodynamics for non-equilibrium systems.

Unit No.	Topics to be Covered Lecture	Lecture Hours	Learning Outcomes
1	Introduction: Review of basic thermodynamics, First law for a closed system, Caratheodory's approach, Uncoupled and coupled systems, General conservation of energy principle for control volume, Transient flow analysis, Charging and discharging of rigid vessels, Transient analysis with boundary work	6L + 2T	Understanding of basic concepts and applying the conservation of energy principle to both control mass and control volumes, both for steady and transient conditions
2	Second Law of Thermodynamics and Entropy: Physical meaning of Second law, Statement of Second law, External and internal irreversibility, Introduction to entropy, its statistical interpretation, Caratheodory's axiom II, Entropy balance equation for closed system and control volume. Entropy measurement and its evaluation, Mechanism of entropy generation: Heat transfer across finite temperature difference, Flow with friction, Mixing. Entropy generation number	7L + 3T	This unit will help the students to understand the limitations of first law and how 2nd law will be useful in overcoming the same. The student will be able to apply the entropy balance to both closed and open systems with view to estimating the related entropy generation in various engineering devices
3	Exergy: Introduction, Availability and exergy of systems Availability or exergetic efficiency, Generalized exergy analysis	6L +2T	This unit will make the student understand the concept of exergy and to estimate the available and unavailable part of any low grade energy source
4	Thermodynamic Property Relations:	6L +2T	This chapter will familiarize the

	Introduction, The Maxwell's relations, The Gibbs and Helmholtz relations, The Clapeyron Equation, General relations involving enthalpy, internal energy and entropy, Co-efficient of volumetric expansion, Isothermal compressibility. Joule Thomson coefficient, Jacobeans' in Thermodynamics		students with thermodynamic property relations, using which the student will be able to estimate different calculated thermodynamic properties from the measured ones
5	Non-Reactive Gas Mixtures: Introduction, basic definitions for gas mixtures, PVT relationship for mixtures of ideal gases, entropy change due to mixing	6L +2T	This will help the students to calculate various thermodynamic properties of homogeneous gas mixtures from the known properties the constituents
6	Reactive Gas Mixtures: Introduction, fuels and combustion, theoretical and actual combustion processes, enthalpy of formation and enthalpy of reaction, adiabatic flame temperature, first and second law analysis of reacting systems, Chemical exergy	6L +2T	Upon successful completion of this chapter student will be able to apply 1st and 2nd law to reacting systems and to estimate the heat reaction, adiabatic flame temperature etc
7	Irreversible thermodynamics: Introduction to irreversible thermodynamics, Onsager's reciprocal theorem	5L + 1T	This chapter will help the student understand the theory and concept of thermodynamics for non-equilibrium systems
	Total	**42L+14T**	

Text Books

1. Kenneth Wark, McGraw-Hill, Advanced thermodynamics for engineers, 3rd Edition, 2013.

Reference books

1. D. E. Winterbone and Ali Turan, Advanced Thermodynamics for Engineers, 2nd Edition, Elsevier, 2015.

2. Sonntag, Borgnakke and Van Wylen, Fundamentals of Thermodynamics , 7th Edition, John Wiley & Sons, 2009.