THERMODYNAMICS

Course Code: 22ME1104	L	T	P	C
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Note: Use of steam tables permitted in examination.

Course Outcomes: At the end of the course, the student will be able to

CO1 describe thermodynamic systems, properties and apply first law of thermodynamics to non-flow and flow processes

CO2 apply second law of thermodynamics and Carnot's principle to analyze the performance of heat engine, refrigerator and heat pump

CO3 determine the entropy changes in different applications to analyze the reversibility or irreversibility of a process

CO4 determine change in thermodynamic properties in a process using steam tables and Mollier chart

CO5 explain the importance of Maxwell and *T-ds* equations and analyze the performance of different air standard cycles

UNIT-I 10 Lectures

Introduction: Basic Concepts – Macroscopic and microscopic viewpoints, thermodynamic system and control volume – closed, open and isolated systems – intensive and extensive properties, quasi-static process, point and path function, forms of energy, ideal gas and real gas, zeroth law of thermodynamics – measurement of temperature.

First law of Thermodynamics: Joule's experiment – first law of thermodynamics, corollariesperpetual motion machine of first kind, first law applied to non-flow and flow processes- limitations of first law of thermodynamics.

Learning Outcomes: At the end of this unit, the student will be able to

1. describe various types of thermodynamic systems and their properties (L2)
2. discuss the application of zeroth law of thermodynamics in temperature measurement (L2)
3. apply the first law of thermodynamics to non-flow and flow processes (L3)

UNIT-II 10 Lectures

Second Law of Thermodynamics: Distinction between heat and work – cyclic heat engine – energy reservoirs – Kelvin-Planck statement of second law – Clausius statement of second law – refrigerator and heat pump – equivalence of Kelvin-Planck and Clausius statements – perpetual motion machines of second kind – reversibility and irreversibility. Carnot cycle – Carnot theorem – Carnot efficiency.

Learning Outcomes: At the end of this unit, the student will be able to

1. explain Kelvin-Planck and Clausius statements and discuss their equivalence and corollaries (L3)
2. describe the working principle of heat engine, heat pump and refrigerator (L2)
3. explain Carnot cycle and illustrate Carnot theorem (L3)

UNIT-III 10 Lectures

Entropy: Clausius theorem - the property of entropy – the inequality of Clausius – entropy change in an irreversible process – entropy principle – applications of entropy principle – maximum work obtainable from a finite body and a thermal energy reservoir – entropy transfer with heat flow - entropy generation in a closed and open systems. Definition of available energy, exergy and irreversibility.

Learning Outcomes: At the end of this unit, the student will be able to

1. describe the property of entropy using Clausius theorem and inequality of Clausius (L2)
2. determine the change in entropy and entropy generation of various thermodynamic processes (L2)
3. apply entropy principle to describe the performance of thermodynamic systems (L3)

UNIT-IV 10 Lectures

Properties of Pure Substances: Pure Substances – P-V-T surfaces – *T-s* and *h-s* diagram, Mollier chart – dryness fraction – property tables – analysis of steam undergoing various thermodynamic processes using Mollier chart – dryness fraction measurement.

Learning Outcomes: At the end of this unit, the student will be able to

1. explain the properties of a pure substance through P-V-T relationships (L3)
2. determine the properties of steam using steam tables (L3)
3. analyze various thermodynamic processes using Mollier chart (L4)

UNIT-V 10 Lectures

Thermodynamic Relations: Maxwell equations, *T-ds* equations, difference in heat capacities, ratio of heat capacities, energy equation, Joule-Thompson coefficient, Clausius-Clapeyron equation.

Air Standard Cycles: Otto, Diesel and dual cycles, P-V and *T-s* diagrams - description and efficiencies, mean effective pressures. Comparison of Otto, Diesel and dual cycles.

Learning Outcomes: At the end of this unit, the student will be able to

1. discuss Maxwell and *T-ds* equations (L2)
2. describe specific heats, internal energy, enthalpy and Joule-Thompson coefficient (L1)
3. analyze performance of various air standard cycles (L4)

Text Book:

P.K. Nag, *Engineering Thermodynamics*, 5th Edition, Tata McGraw Hill, 2013.

Reference Books:

1. Yunus A. Cengel and Michaela A. Boles, *Thermodynamics,* 7th Edition, Tata McGraw Hill, 2011.
2. Claus Borgnakke Richard E. Sonntag, *Fundamentals of Thermodynamics*, 7th Edition, Wiley, 2009.
3. J.P. Holman, *Thermodynamics*, 4th Edition, McGraw Hill Publishers, 1988.

Data Books:

1. C.P. Kothandaraman, *Steam Tables,* 4th Edition, New Age International (P) Ltd Publishers, 2015.
2. R.S. Khurmi and N. Khurmi, *Steam Tables with Mollier Diagram* (in SI Units), S. Chand.