Thermodynamics

L	T	P	C
3	0	0	3

Course Objectives

- Familiarize concepts of heat, work, energy and governing rules for conversion of one form to other.
- Explain relationships between properties of matter and basic laws of thermodynamics.
- Teach the concept of entropy for identifying the disorder and feasibility of a thermodynamic process.
- Introduce the concept of available energy for maximum work conversion.
- Familiarize steam properties to understand working of steam power plants.
- Provide fundamental concepts of thermodynamics cycles used in steam power plants, IC engines and gas turbines.

UNIT I: **10 hours**

Introduction: Basic Concepts: Macroscopic and microscopic viewpoints, definitions of thermodynamic terms, quasi – static process, point and path function, forms of energy, ideal gas and real gas, Zeroth law of thermodynamics.

First law of Thermodynamics: Joule's experiment – firstlaw of thermodynamics, corollaries – perpetual motion machines of first kind, first law applied to non-flow and flow process- limitations of first law of thermodynamics.

Learning outcomes

At the end of this Unit, the student will be able to

- Identify thermodynamic systems, properties and their importance in solving engineering problems. (L3)
- Explain energy balance for closed systems and open systems. (L4)
- Solve simple thermodynamics problems. (L3)

UNIT II: **8 hours**

Second Law of Thermodynamics: Kelvin –Planckstatement and Clausius statement and their equivalence, corollaries –perpetualmotion machines of second kind – reversibilityand irreversibility, cause of irreversibility – Carnotcycle, heat engine, heat pump and refrigerator, Carnot theorem, Carnot efficiency.

Learning outcomes

At the end of this Unit, the student will be able to

- Apply second law of thermodynamics in design of heat engine, refrigerator and heat pump. (L3)

- Explainthe efficiencyof thermodynamic systems.(L2)
- Enumerate the causes for poor performance of thermodynamic systems. (L3)

UNIT III: **8 hours**

Entropy: Clausius inequality –Conceptof Entropy – entropyequation for different processes and systems

Availability and Irreversibility: Definition of exergy and anergy, expressions for availability and irreversibility. Availability in steady flow, non-flow processes and irreversibility.

Learning outcomes

At the end of this Unit, the student will be able to

- Apply entropy affects to estimate the performance of systems. (L3)
- Evaluate entropy changes in a wide range of processes and determine the reversibility or irreversibility of a process. (L4)
- Explain thermo-economics.(L3)

UNIT IV: **8 hours**

Properties of Steam and use of Steam Tables: 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– steam calorimetry.

Learning outcomes

At the end of this Unit, the student will be able to

- Apply properties of steam to design steam systems. (L3)
- Examine steam systems using conservation equations. (L4)
- Evaluate the performance of steam systems. (L4)

UNIT V: **8 hours**

Thermodynamic Relations: Maxwell relations, TdS 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.

Vapour Power Cycles: Vapour power cycle, simple Rankine cycle, mean temp of heat addition thermodynamic variables effecting efficiency and output ofRankine cycle.

Learning outcomes

At the end of this Unit, the student will be able to

- Explain the importance of T-ds equations. (L3)
- Relate specific heats, internal energy, enthalpy and Joule-Thomson coefficient in standard form.

(L3)

- Examine the importance of compression ratio. (L4)
- Explain the cycles on which internal combustion engines work. (L3)

Text Book(s)

1. P.K.Nag, Engineering Thermodynamics, 5/e, Tata McGraw Hill, 2013.
2. Yunus A. Cengel, Michaela A. Boles, Thermodynamics, 7/e, Tata McGraw Hill, 2011.

References

1. J.B.Jones and G.A.Hawkins, Introduction to Thermodynamics, 2/e, John Wiley & Sons, 2012.
2. Moran, Michael J. and Howard N. Shapiro, Fundamentals of Engineering Thermodynamics, 3/e, Wiley, 2015
3. Claus Borgnakke Richard E. Sonntag, Fundamentals of Thermodynamics, 7/e, Wiley, 2009
4. R.K. Rajput, S.Chand& Co., Thermal Engineering, 6/e, Laxmi publications, 2010.

Course Outcomes

After completing the course, the student will be able to

- Explain the importance of thermodynamic propertiesrelated to conversion of heat energy into work. (L3)
- Apply the laws of thermodynamics to boilers, heat pumps, refrigerators, heat engines, compressors and nozzles. (L3)
- Utilize steam properties to design steam based components. (L4)
- Compare thermodynamic relations and air standard cycles. (L4)