ENGINEERING THERMODYNAMICS I

ENME 104

Lecture : 3 **Year : I**
Tutorial : 1 **Part : I**
Practical : 1.5

Course Objectives:
To develop the laws of thermodynamics and their practice with real-world engineering examples.

1 Introduction (3 hours)

1.1 Thermodynamics and its applications
1.2 Thermodynamic system: Control mass, control volume
1.3 Macroscopic versus microscopic point of view
1.4 Properties and state of a substance: Intensive and extensive
1.5 Processes and cycles: Thermodynamic equilibrium
1.6 Specific volume, pressure
1.7 Temperature: Equality of temperature

2 Energy and Energy Transfer (4 hours)

2.1 Energy
  2.1.1 Potential, internal and kinetic energy
  2.1.2 Stored and transient energy
2.2 Work transfer
  2.2.1 Definition of work
  2.2.2 Moving boundary works
  2.2.3 Other examples of work
2.3 Energy transfer
  2.3.1 Heat transfer
  2.3.2 Heat transfer modes

3 Properties of Pure Substance (6 hours)

3.1 Pure substance and state postulate
3.2 Phase-change processes of pure substances
3.3 Property diagrams for phase-change processes
  3.3.1 The T-V and the P-V diagram
  3.3.2 Properties of two-phase mixtures
  3.3.3 The P-T diagram
  3.3.4 The P-V-T surface
3.4 Tables of thermodynamic properties

3.5 Ideal gas, ideal-gas state and ideal-gas relations
3.6 The compressibility factor

4 First Law of Thermodynamics (4 hours)

4.1 First law of thermodynamics for control mass
4.1.1 Control mass undergoing a cycle
4.1.2 Control mass undergoing a change in state
4.2 Thermodynamic properties: Internal energy, enthalpy
4.3 Specific heats of ideal gases
4.4 Rate law as a rate equation
4.5 Conservation of mass

5 First-Law Analysis for a Control Volume (4 hours)

5.1 Conservation of mass and control volume
5.2 First law of thermodynamics for control volume
5.3 Steady-state process
5.4 Examples of steady-state processes
5.5 Transient process

6 Second Law of Thermodynamics (3 hours)

6.1 Heat engines and refrigerators
6.2 Second law of thermodynamics
6.3 Reversible and irreversible processes
6.4 Carnot cycle
6.5 Thermodynamic temperature scale and ideal-gas temperature scale
6.6 Ideal versus real machines

7 Entropy (4 hours)

7.1 Clausius inequality
7.2 Entropy- A property of a system
7.2.1 Entropy of a pure substance
7.2.2 Entropy change in reversible processes
7.2.3 Thermodynamic property relation
7.3 Entropy change of a control mass
7.3.1 Entropy generation
7.3.2 Principle of the increase of entropy
7.3.3 Entropy change of a solid or liquid
7.3.4 Entropy change of an ideal gas
7.4 Entropy as a rate equation

8 Second-Law Analysis for a Control Volume (4 hours)

8.1 Second law of thermodynamics for a control volume
8.2 Steady-state process and transient process
8.3 Reversible steady-state process
8.4 Principle of increase of entropy
8.5 Efficiency

9 Irreversibility and Availability (4 hours)

9.1 Available energy, reversible work and irreversibility
  9.1.1 Steady-state process
  9.1.2 Control mass process
  9.1.3 Transient process
9.2 Availability and second-law efficiency
9.3 Energy balance equation

10 Thermodynamic Relations (6 hours)

10.1 Clapeyron equation
10.2 Mathematical relations for a homogeneous phase
10.3 Maxwell relations
10.4 Thermodynamic relations
10.5 Expansivity and compressibility
10.6 Real-gas behavior and equations of state
10.7 Generalized chart for changes in enthalpy
10.8 Generalized chart for changes in entropy
10.9 Developing tables of thermodynamic properties

11 Gas Mixtures (3 hours)

11.1 Mixture of ideal gases: Dalton model
11.2 Mixture involving gases and a vapor
11.3 First law applied to gas-vapor mixture
11.4 Mixture of air and water-vapor
  11.4.1 Adiabatic saturation process
  11.4.2 Introduction to psychrometric chart

Tutorials (15 hours)

1. Sample problems related to the thermodynamic properties and displacement transfer
2. Sample problems related to properties of liquid-vapor mixture system
3. Sample problems related to mass and energy conservation of control mass, cyclic process, control volume
1. Sample problems related to entropy change, entropy generation for ideal gas, isolated system, control mass and control volume, isentropic efficiencies
4. Sample problems related to performance of heat engine and heat pump

5. Sample problems related to availability, second law efficiency and evaluating properties of mixtures
6. Sample problems related to thermodynamic relations and charts

Assignments

1. Thermodynamic properties measurement and energy transfer
2. Properties of pure substances
3. First law of thermodynamics
4. Second law of thermodynamics
5. Irreversibility and availability
6. Thermodynamic relations
7. Gas mixtures

Laboratory **(22.5 hours)**

1. Temperature measurements
2. To Validate the pressure as an intensive property/ to find dryness fraction of steam
3. Experiment related to first law (Joules experiment to validate first law of thermodynamics)
4. Experiment related to second law (Cooling of hot water)
5. Isentropic efficiency calculation of turbines, nozzles, etc.
6. Development of graph representing the tables of thermodynamic properties
7. Case study: Thermoeconomic analysis of any thermal system

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	3	4
2	4	5
3	6	8
4	4	5
5	4	6
6	3	4
7	4	5
8	4	6
9	4	5
10	6	8
11	3	4
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Van Wylen, G.J., Sonntag, R.E., Borgnakke, C. (2025). Fundamentals of Thermodynamics. John Wiley & Sons.
2. Moran, M.J., Shapiro, H.N., Boettner, D.D., Bailey, M.B. (2017). Fundamentals of Engineering Thermodynamics. John Wiley & Sons.
3. Çengel, Y.A., Boles, M.A. (2019). Thermodynamics: An Engineering Approach. McGraw-Hill Education.