BASIC THERMODYNAMICS

Module 1: Fundamental Concepts & Definitions (5)

Thermodynamics: Terminology; definition and scope, microscopic and macroscopic approaches. Engineering Thermodynamics: Definition, some practical applications of engineering thermodynamics. System (closed system) and Control Volume (open system); Characteristics of system boundary and control surface; surroundings; fixed, moving and imaginary boundaries, examples. Thermodynamic state, state point, identification of a state through properties; definition and units, intensive and extensive various property diagrams, path and process, quasi-static process, cyclic and non-cyclic processes; Restrained and unrestrained processes; Thermodynamic equilibrium; definition, mechanical equilibrium; diathermic wall, thermal equilibrium, chemical equilibrium. Zeroth law of thermodynamics. Temperature as an important property.

Module 2: Work and Heat (5)

Mechanics definition of work and its limitations. Thermodynamic definition of work and heat, examples, sign convention. Displacement works at part of a system boundary and at whole of a system boundary, expressions for displacement works in various processes through p-v diagrams. Shaft work and Electrical work. Other types of work. Examples and practical applications.

Module 3: First Law of Thermodynamics (5)

Statement of the First law of thermodynamics for a cycle, derivation of the First law of processes, energy, internal energy as a property, components of energy, thermodynamic distinction between energy and work; concept of enthalpy, definitions of specific heats at constant volume and at constant pressure. Extension of the First law to control volume; steady state-steady flow energy equation, important applications such as flow in a nozzle, throttling, adiabatic mixing etc., analysis of unsteady processes, case studies.

Module 4: Pure Substances & Steam Tables and Ideal & Real Gases (5)

Ideal and perfect gases: Differences between perfect, ideal and real gases, equation of state, evaluation of properties of perfect and ideal gases. Real Gases: Introduction. Van der Waal's Equation of state, Van der Waal's constants in terms of critical properties, law of corresponding states, compressibility factor; compressibility chart, and other equations of state (cubic and higher orders). Pure Substances: Definition of a pure substance, phase of a substance, triple point and critical points, sub-cooled liquid, saturated liquid, vapor pressure, two-phase mixture of liquid and vapor, saturated vapor and superheated vapor states of a pure substance with water as example. Representation of pure substance properties on p-T and p-V diagrams, detailed treatment of properties of steam for industrial and scientific use (IAPWS-97, 95)

Module 5: Basics of Energy conversion cycles (3)

Devices converting heat to work and vice versa in a thermodynamic cycle Thermal reservoirs. Heat engine and a heat pump; schematic representation and efficiency and coefficient of performance. Carnot cycle.

Module 6: Second Law of Thermodynamics (5)

Identifications of directions of occurrences of natural processes, Offshoot of II law from the I. Kelvin-Planck statement of the Second law of Thermodynamic; Clasius's statement of Second law of Thermodynamic; Equivalence of the two statements; Definition of Reversibility, examples of reversible and irreversible processes; factors that make a process irreversible, reversible heat engines; Evolution of Thermodynamic temperature scale.

Module 7: Entropy (5)

Clasius inequality; statement, proof, application to a reversible cycle. $\oint (\delta Q_R/T)$ as independent of the path. Entropy; definition, a property, principle of increase of entropy, entropy as a quantitative test for irreversibility, calculation of entropy, role of T-s diagrams, representation of heat, Tds relations, Available and unavailable energy.

Module 8: Availability and Irreversibility (2)

Maximum work, maximum useful work for a system and a control volume, availability of a system and a steadily flowing stream, irreversibility. Second law efficiency.

Lecture Plan

Module	Learning Units	Hours per topic	Total Hours
1. Fundamental Concepts & Definitions	1. Thermodynamics; Terminology; definition and scope, Microscopic and Macroscopic approaches. Engineering Thermodynamics; Definition, some practical applications of engineering thermodynamics.	1	5
	2. System (closed system) and Control Volume (open system); Characteristics of system boundary and control surface; surroundings; fixed, moving and imaginary boundaries, examples.	1	
	3. Thermodynamic state, state point, identification of a state through properties; definition and units, intensive and extensive various property diagrams,	1	
	4. Path and process, quasi-static process, cyclic and non-cyclic processes; Restrained and unrestrained processes;	1	
	5. Thermodynamic equilibrium; definition, mechanical equilibrium; diathermic wall, thermal equilibrium, chemical equilibrium. Zeroth law of thermodynamics, Temperature as an important property.	1	
2. Work and Heat	6. Mechanics definition of work and its limitations. Thermodynamic definition of work and heat; examples, sign convention.	1	5
	7. Displacement work; at part of a system boundary, at whole of a system boundary,	2	
	8. Expressions for displacement work in various processes through p-v diagrams.	1	
	9. Shaft work; Electrical work. Other types of work, examples of practical applications	1	
3. First Law of Thermo-dynamics	10. Statement of the First law of thermodynamics for a cycle, derivation of the First law of processes,	1	5
	11. Energy, internal energy as a property, components of energy, thermodynamic distinction between energy and work; concept of enthalpy, definitions of specific heats at constant volume and at constant pressure.	1	
	12. Extension of the First law to control volume; steady state-steady flow energy equation,	1	
	13. Important applications such as flow in a nozzle, throttling, and adiabatic mixing etc. analysis of unsteady processes, case studies.	2	
4. Pure Substances &	14. Differences between perfect, ideal and real gases. Equation of state. Evaluation of properties of perfect and ideal gases	1	

Steam Tables and Ideal & Real Gases	15. Introduction. Van der Waal's Equation of state, Van der Waal's constants in terms of critical properties, law of corresponding states, compressibility factor; compressibility chart. Other equations of state (cubic and higher order)	1	5
	16. Definition of a pure substance, phase of a substance, triple point and critical points. Sub-cooled liquid, saturated liquid, vapour pressure, two phase mixture of liquid and vapour, saturated vapour and superheated vapour states of a pure substance	1	
	17. Representation of pure substance properties on p-T and p-V diagrams, Detailed treatment of properties of steam for industrial and scientific use (IAPWS-97, 95)	2	
5. Basics of Energy conversion cycles	18. Devices converting heat to work and vice versa in a thermodynamic cycle, thermal reservoirs. heat engine and a heat pump	1	3
	19. Schematic representation and efficiency and coefficient of performance. Carnot cycle.	2	
6. Second Law of Thermo-dynamics	20. Identifications of directions of occurrences of natural processes, Offshoot of II law from the Ist. Kelvin-Planck statement of the Second law of Thermodynamic;	2	5
	21. Clasius's statement of Second law of Thermodynamic; Equivalence of the two statements;	1	
	22. Definition of Reversibility, examples of reversible and irreversible processes; factors that make a process irreversible,	1	
	23. Reversible heat engines; Evolution of Thermodynamic temperature scale.	1	
7. Entropy	24. Clasius inequality; statement, proof, application to a reversible cycle. $\oint (\delta Q_R/T)$ as independent of the path.	1	5
	25. Entropy; definition, a property, principle of increase of entropy, entropy as a quantitative test for irreversibility,	1	
	26. Calculation of entropy, role of T-s diagrams, representation of heat quantities; Revisit to 1st law	2	
	27. Tds relations, Available and unavailable energy.	1	
8. Availability and Irreversibility	28. Maximum work, maximum useful work for a system and a control volume,	1	2
	29. Availability of a system and a steadily flowing stream, irreversibility. Second law efficiency	1	