THERMODYNAMICS

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INTENDED AUDIENCE : Undergraduate students of mechanical engg., and possibly aero- engg. Also any person interested in the basics of energy conversion. Students preparing for GATE, etc.

PRE-REQUISITES: : 12 th standard science (PCM or PCB), and basic knowledge of differential calculus.

INDUSTRY SUPPORT : : The course encompasses power generation, I.C.engines, process engineering, refrigeration and air-conditioning, and energy conversion in general, amongst others.

COURSE OUTLINE :

This course is on basic engineering thermodynamics. The first part, on single component systems, topics are basic concepts and definitions, conservation of mass, 1st and 2nd laws of thermodynamics for closed and open systems, thermodynamic properties of a pure substance and practical applications. The second part covers physical behaviour of a mixture of ideal gases, psychrometry, thermodynamics of reacting systems, combustion, phase and chemical equilibrium, and applications.Lecture notes will be provided and supplemented with assignments that emphasize systematic problem solving.

ABOUT INSTRUCTOR :

Professor Sunil R. Kale has been with the Department of Mechanical Engineering since 1989. He has developed and taught UG courses (thermodynamics, energy conversion, heat and mass transfer, power plant technologies, engineering drawing, and mechanical core laboratory), and PG courses (experimental methods for thermal engineering, multiphase flows). His research, academic and industry-related, is in the fields of heat transfer, fluid mechanics, fire dynamics, combustion, and energy conversion.

COURSE PLAN:

Week 1 : Concepts & definitions. Heat. Work. Equilibrium. Reversible process. Steady state. System, boundary. Control mass, control volume. State. Properties

Week 2 : Conservation of mass for closed and open systems and Internal energy and Enthalpy

Week 3 : First Law of Thermodynamics. 1st law for closed and open systems. SSSF and USUF processes.

Week 4 : Second Law. Clausius inequality. Entropy. 2 nd law for closed and open systems.Carnot's cycle

Week 5 : Thermodynamic behavior of a pure substance. Solid, liquid and vapour phases.Thermodynamic properties of a pure substance. Property relations.

Week 6 : Carnot's cycle realization – in closed and open systems for ideal gas and vapour states.Practical limitations. Modifications to realize it.

Week 7 : Thermodynamics of engineered equipment: turbine, compressor, pump, heat exchanger, diffuser, nozzle, throttling, flow through pipes/ducts, etc.

Week 8 : Practical cycles and processes. Rankine cycle and its modifications. Ideal gas cycles.Heat engine and heat pump/refrigeration cycles (VCR and VAM).

Week 9 : Mixtures of ideal gases – Physical behaviour of non-reacting mixtures of ideal gases. Gas-vapor mixtures and their thermodynamic properties.

Week 10 : Psychrometry and its applications. Specific and relative humidity. Dew point.Saturation and wet bulb temperature. Psychrometric chart. Conditioning of air and applications (air-evaporative cooling, cooling towers, humidification,etc.

Week 11 : Mixtures of ideal gases – Reacting systems. 1-step reactions. Stoichiometry, equivalenc ratio. Enthalpy of formation. Conservation of mass. 1 st law analysis.Heat of reaction and properties. Adiabatic flame temperature. Work of reaction.Enthalpy of formation. 2 nd law analysis. Application to combustion, fuel cells.Introduction to multi-step reactions and minor species.

Week 12 : Phase and chemical equilibrium. Phase equilibrium of single- and multi-component systems. Equilibrium constant for ideal-gas mixtures. Simultaneous reactions. Applications.