ADVANCED THERMODYNAMICS

Course Code: 13ME2302

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Course Outcomes:

At the end of the course, student will be able to

CO1 : Apply the concept of entropy and irreversibility to solve practical problems.

CO2 : Explain P-V, T-S, P-T and h-s diagrams of pure substance and its significance.

CO3 : Distinguish the equations of state for ideal and real gases and gas mixtures.

CO4 : DevelopTdS, Maxwell's equations and power cycles.

CO5 : Explain thermodynamic distribution function and partition function in statistical thermodynamics.

UNIT-I

Entropy: Clausius theorem - the property of entropy – the inequality of Clausius – entropy change in an irreversible process – entropy principle – applications of entropy principle to the processes of transfer of heat through a finite temperature difference, and mixing of two fluids maximum work obtainable from a finite body and a thermal energy reservoir – entropy transfer with heat flow - entropy generation in a closed system – entropy generation in an open system.

UNIT-II

Available energy: Available energy referred to a cycle - available energy from a finite energy source – maximum work in a reversible process – dead state – availability in a steady flow process – availability in a non-flow process – availability in chemical reactions.

P-V-T Relationships for pure substances: P-v diagram for a pure substance, triple point line, critical point, saturated liquid and vapor lines, P-T diagram for a pure substance - T-s diagram for a pure substance – h-s diagram (Mollier diagram) for a pure substance – dryness fraction – problems using steam tables.

UNIT-III

Properties of Gases: Equations of state – Vander Waal's equation – law of corresponding states – Beattie-Bridgeman equation, Redlich-Kwong equation.

Gas Mixtures: Dalton's law of partial pressures – enthalpy and entropy of gas mixtures.

Reactive Systems: Degree of reaction – reaction equilibrium – law of mass action – heat of reaction – temperature dependence of the heat of reaction – temperature dependence of the equilibrium constant – change in Gibbs function – Fugacity and activity.

UNIT-IV

Thermodynamic Relations: Maxwell's equations –TdS equations – difference in heat capacities – ratio of heat capacities – Joule-Kelvin effect – Clausius-Clapeyron equation.

Power Cycles: Brayton cycle – comparison between Brayton cycle and Rankine cycle – effect of regeneration on Brayton cycle efficiency – Brayton-Rankine combined cycle.

Statistical Thermodynamics-I: Thermodynamic equilibrium distribution – thermodynamic distribution function – thermodynamic ensemble, micro canonical ensemble, canonical ensemble, grand canonical ensemble.

UNIT-V

Statistical Thermodynamics-II: Maxwell-Boltzmann statistics and distribution – Fermi-Dirac statistics and distribution – Bose-Einstein statistics and distribution – phase space – Liouville equation – equilibrium constant by statistical thermodynamic approach.

Partition function – equipartition of energy – partition function for canonical ensemble – partition function for an ideal monoatomic gas – decomposition of partition function – translational partition function – electronic, rotational and vibrational partition functions.

TEXT BOOKS:

1. P.K. Nag, "*Engineering Thermodynamics*", 4th Edition, Tata McGraw-Hill Education Private Limited, 2010.

2. S.S. Thipse, "*Advanced Thermodynamics*", Narosa Publishing House, New Delhi, 2013

REFERENCES:

1. Y.A. Cengel and M.A. Boles, "*Thermodynamics – An Engineering Approach*", 5th Edition in SI Units, Tata McGraw Hill Publishing Company Limited, New Delhi, 2006.

2. C. Borganakke and R.E. Sonntag, "*Fundamentals of Thermodynamics*", 7th Edition,
Wiley India, Delhi, 2012.

3. Van P. Carey, "Statistical thermodynamics and micro scale thermo physics", Cambridge University Press, 1999