# SCHEME OF COURSE WORK

**Course Details:**

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| **Course Title** | **: Advanced Thermodynamics** | | |
| **Course Code** | **: 13ME2302** | **L T P C** | **: 4 0 0 3** |
| **Program:** | **: M.Tech.** | | |
| **Specialization:** | **: Thermal Engineering** | | |
| **Semester** | **: I** | | |
| **Prerequisites** | **: Thermodynamics** | | |

**Course Outcomes (COs):**

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| At the end of the course, student will be able to |
| 1. Apply the concept of entropy and irreversibility to solve practical problems. |
| 2. Explain P-V, T-S, P-T and h-s diagram of pure substance and its significance. |
| 3. Distinguish the equation of state for ideal and real gases and gas mixtures. |
| 4. Develop TdS, Maxwell's equations and power cycles. |
| 5. Explain thermodynamic distribution function and partition function in statistical thermodynamics |

**Program Outcomes (POs):**

A postgraduate of Thermal Engineering will able to

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| PO 1 | exhibit in-depth knowledge in thermal engineering specialization |
| PO 2 | think critically and analyze complex engineering problems to make creative advances in theory and practice |
| PO 3 | solve problem, think originally and arrive at feasible and optimal solutions with due consideration to public health and safety of environment |
| PO 4 | use research methodologies, techniques and tools, and will contribute to the development of technological knowledge |
| PO 5 | apply appropriate techniques, modern engineering tools to perform modeling of complex engineering problems with knowing the limitations |
| PO 6 | understand group dynamics, contribute to collaborative multidisciplinary scientific research |
| PO 7 | demonstrate knowledge and understanding of engineering and management principles and apply the same with due consideration to economical and financial factors |
| PO 8 | communicate complex engineering problems with the engineering community and society, write and present technical reports effectively |
| PO 9 | engage in life-long learning with a high level of enthusiasm and commitment to improve knowledge and competence continuously |
| PO10 | exhibit professional and intellectual integrity, ethics of research and scholarship and will realize the responsibility towards the community |
| PO11 | examine critically the outcomes of actions and make corrective measures |

**Course Outcome** versus **Program Outcomes:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | S | M | M | | M | | | | M | | |
| **CO2** | S | M | | | | M | | | M | | |
| **CO3** | S | M | | | | M | | M | M | | |
| **CO4** | S | M | M | M | M | | | M | M | M | |
| **CO5** | S | S | | M | M | M | | M | M | M | |

*S* - Strongly correlated, *M - Moderately* correlated, *Blank - No correlation*

| **Assessment Methods:** | Assignment / Quiz / Seminar / Case Study / Mid-Test / End Exam |
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## Teaching-Learning and Evaluation

| Week | TOPIC / CONTENTS | Course Outcomes | Sample questions | TEACHING-LEARNING STRATEGY | Assessment Method & Schedule |
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| 1 | Introduction, clausius theorem and inequality of entropy | CO1 | Establish clausius inequality | ▫ Lecture<br>▫ Demo class | |
| 2 | Principle of entropy and its applications | CO1 | Derive change in entropy of mixing of two fluids | ▫ Lecture<br>▫ Discussion | **Assignment- 1 (Week 2- 6)** |
| 3 | Entropy generation in open and closed systems | CO1 | Show that entropy generation is not a property | ▫ Lecture<br>▫ Discussion | |
| 4 | Introduction on availability and maximum work in a reversible process | CO2 | Write a shot note on dead state | ▫ Lecture<br>▫ Discussion | |
| 5 | Availability in steady, non flow process and chemical reactions | CO2 | Any problem on availability and irreversibility | ▫ Lecture<br>▫ Problem solving | |
| 6 | P-v, T-s, P-T and h-s diagram for pure substance and measurement method for dryness fraction | CO2 | Explain h-s diagram? Why the constant pressure lines are diverges one another | ▫ Lecture<br>▫ Problem solving | |
| 7 | Equation of state, vander waals equation and law of corresponding states | CO3 | Explain law of corresponding states | ▫ Lecture<br>▫ Discussion | |
| 8 | Beattie-Bridgeman equation and Redlich-Kwong equation | CO3 | Problem on any equation by using generalized compressibility chart | ▫ Lecture<br>▫ Discussion | |
| 9 | **Mid-Test 1** | | | | **Mid-Test 1 (Week 9)** |
| 10 | Dalton's law of partial pressures, enthalpy and entropy of gas mixture | CO3 | Problem on mixing of gases | ▫ Lecture<br>▫ Discussion<br>▫ Problem solving | |
| 11 | Degree of reaction, reaction equilibrium, law of mass action and heat of reaction | CO3 | What is law of mass action and heat of reaction | ▫ Lecture<br>▫ Discussion | **Assignment- 2 (Week 11- 16)** |
| 12 | Temperature dependence of the heat reaction, equilibrium constants, change in Gibbs function, fugacity and activity | CO3 | Explain fugacity and activity | ▫ Lecture<br>▫ Discussion | |
| 13 | Thermodynamic relations | CO4 | Derive Maxwell relations | ▫ Lecture<br>▫ Discussion | |
| 14 | Brayton cycle, comparison between Brayton and Rankine cycle | CO4 | Compare Brayton and Rankine cycles | ▫ Lecture<br>▫ Discussion | |
| 15 | Thermodynamic distribution function, ensemble, micro canonical ensemble, | CO4 | Explain the terms ensemble and canonical ensemble | ▫ Lecture<br>▫ Discussion | |

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| | canonical ensemble and grand canonical ensemble. | | | | |
| 16 | Maxwell – Boltzmann, Fermi-Dirac and Bose-Einstein statistics and distribution | CO5 | What is Fermi-Dirac statistics and distribution | ▫ Lecture<br>▫ Discussion | |
| 17 | Liouville equation, equilibrium constant by statistical thermodynamic approach | CO5 | describe Liouville equation for statistical thermodynamic approach | ▫ Lecture<br>▫ Discussion | |
| 18 | Partition function for ideal monoatomic gas, decomposition, translational, electronic, rotational and vibrational | CO5 | Write down the partition function for ideal monoatomic gas | ▫ Lecture<br>▫ Discussion | |
| 19 | **Mid-Test 2** | | | | **Mid-Test 2 (Week 19)** |
| 20/21 | **END EXAM** | | | | **END EXAM** |