SCHEME OF COURSE WORK:

Course Details:

Course Title	**Advanced Thermodynamics**					
Course Code	19ME2202	**LTPC**	**3**	**0**	**0**	**3**
Program	M.Tech.					
Specialization	Thermal Engineering					
Semester	I					
Prerequisites	Engineering Thermodynamics					
Course to which is a prerequisite	NA					

Course Outcomes:

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	Develop TdS, Maxwell's equations and power cycles.
CO5	Explain reactive system and its significance in combustion process.

Program Outcomes:

PO Code	Program Outcome (PO)
PO1	exhibit in-depth knowledge in thermal engineering specialization
PO2	think critically and analyse complex engineering problems to make creative advances in theory and practice
PO3	solve problem, think originally and arrive at feasible and optimal solutions with due consideration to public health and safety of environment
PO4	use research methodologies, techniques and tools, and will contribute to the development of technological knowledge
PO5	apply appropriate techniques, modern engineering tools to perform modelling of complex engineering problems with knowing the limitations
PO6	understand group dynamics, contribute to collaborative multidisciplinary scientific research
PO7	demonstrate knowledge and understanding of engineering and management principles and apply the same with due consideration to economical and financial factors
PO8	communicate complex engineering problems with the engineering community and society, write and present technical reports effectively
PO9	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 Vs Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M	S			M			M			
CO2	S	M	S			M			M			
CO3	S	M	M									
CO4	S		M									
CO5	S	S	S			M			M			

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

Assessment Methods:
Assignment/Quiz/Seminar/Case Study, Mid term exam and End term examination.

Week	TOPIC / CONTENTS	Course Outcomes	Sample questions	TEACHING-LEARNING STRATEGY	Assessment Method & Schedule
1	Introduction, Clausius theorem and inequality of entropy	CO1	Establish Clausius inequality	▫ Lecture ▫ Demo class	
2	Principle of entropy and its applications	CO1	Derive change in entropy of mixing of two fluids	▫ Lecture ▫ Discussion	**Assignment- 1 (Week 2- 6)**
3	Entropy generation in open and closed systems	CO1	Show that entropy generation is not a property	▫ Lecture ▫ Discussion	
4	Introduction on availability Available energy referred to a cycle - available energy from a finite energy source maximum work in a reversible process	CO2	Write a shot note on dead state	▫ Lecture ▫ Discussion	
5	dead state – availability in a steady flow process – availability in a non-flow process – availability in chemical reactions	CO2	Any problem on availability and irreversibility	▫ Lecture ▫ Problem solving	
6	Properties of Pure Substance: 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	CO2	Explain the phase change of a pure substance on P-V,T-S and P-T coordinate system	▫ Lecture ▫ Problem solving	
7	h-s diagram (Mollier diagram) for a pure Substance – dryness fraction – problems using steam tables.	CO2	Explain h-s diagram and Why the constant pressure lines are diverges one another?	▫ Lecture ▫ Discussion	
8	Properties of Gases: Equations of state – Vander Waal's equation – Beattie-Bridgeman equation, Redlich-Kwong equation	CO3	Explain law of corresponding states	▫ Lecture ▫ Discussion	
9	**Mid-Test 1**				**Mid-Test 1 (Week 9)**
10	law of corresponding states – Compressibility Charts - Gas Mixtures: Dalton's law of partial pressures	CO3	Problem on any equation by using generalized compressibility chart	▫ Lecture ▫ Discussion ▫ Problemsolving	
11	Dalton's law of partial pressures, enthalpy and entropy of gas mixture	CO3	Problem on mixing of gases	▫ Lecture ▫ Discussion ▫ Problem solving	
12	Thermodynamic Relations: Maxwell's equations - TdS equations - difference in heat capacities – ratio of heat capacities – Joule-Kelvin effect – Clausius-Clapeyron equation.	CO4	Derive Maxwell and TdS equation? Explain the Joule-Kelvin effect	▫ Lecture ▫ Discussion ▫ Lecture ▫ Discussion	**Assignment- 2 (Week 11- 16)**
13	Power Cycles: Brayton cycle – comparison	CO4	Explain the working principle	▫ Lecture ▫ Discussion	

	between Brayton cycle and Rankine cycle - effect of regeneration on Brayton cycle efficiency		of gas turbine with inter cooling and regeneration		
14	Problems on Brayton Cycle Brayton-Rankine combined cycle.	CO4	Problems	▫ Lecture ▫ Discussion ▫ Problemsolving	
15	Reactive Systems: Degree of reaction – reaction equilibrium – law of mass action - heat of reaction	CO5	Describe and derive the law of mass action	▫ Lecture ▫ Discussion	
16	Temperature dependence of the heat of reaction Temperature dependence of the equilibrium constant – change in Gibbs function – Fugacity and activity - Chemical Reactions: Combustion, Theoretical and actual combustion processes –	CO5	Define heat of reaction, fugacity and activity Define Combustion and differentiate actual and theoretical combustion	▫ Lecture ▫ Discussion Problemsolving	
17	Enthalpy of formation – Enthalpy of Combustion – First Law analysis of Reacting Systems – Adiabatic flame temperature	CO5	Define Adiabatic Flame Temperature Explain enthalpy of formation and enthalpy of combustion	▫ Lecture Discussion	
18	Adiabatic flame temperature – Entropy change of Reacting mixtures – Second Law analysis of Reacting systems	CO5	Problems	▫ Lecture ▫ Discussion Problemsolving	
19	**Mid-Test 2**				**Mid-Test 2 (Week 19)**