INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTOR

Course Title	**THERMODYANMICS**				
Course Code	AMEB04				
Programme	B. Tech.				
Semester	III	ME			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	-	-
Chief Coordinator	Mr. A Venuprasad, Assistant Professor				
Course Faculty	Dr. P Srinvasa Rao, Professor Mr. A Venuprasad, Assistant Professor				

I. COURSE OVERVIEW:

Thermodynamics is the science that deals with the relationship between heat and work and those properties of systems that bear relation to heat and work. General laws of energy transformations concerning all types of systems, mechanical, electrical and chemical may fall within the purview of this science. It is a science based on a number of empirical laws formed by experimentation from which all predictions concerning the physical behavior of the system may be deduced by logical reasoning. The findings have been formalized into certain basic laws, which are known as Zeroth, First, Second and Third laws of thermodynamics. Power cycles and refrigeration cycle based on thermodynamic system is studied.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AHSB04	I	Waves and Optics	4
UG	AHSB02	I	Linear Algebra and Calculus	4

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
THERMODYNAMICS	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✘	Chalk & Talk	✔	Quiz	✔	Assignments	✘	MOOCs
✔	LCD / PPT	✔	Seminars	✘	Mini Project	✔	Videos
✘	Open Ended Experiments						

V. EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

50 %	To test the objectiveness of the concept.
50 %	To test the analytical skill of the concept OR to test the application skill of the concept.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT).

Table 1: Assessment pattern for CIA

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz - Online Examination

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT)

This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning centre. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc.

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		Strength	Proficiency assessed by
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Presentation on real-world problems
PO 2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	Seminar
PO 4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	Term Paper

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSOs)		Strength	Proficiency assessed by
PSO 1	**Professional Skills:** To produce engineering professional capable of synthesizing and analyzing mechanical systems including allied engineering streams.	1	Seminar
PSO 2	**Software Engineering Practices:** An ability to adopt and integrate current technologies in the design and manufacturing domain to enhance the employability.	-	-
PSO 3	**Successful Career and Entrepreneurship:** To build the nation, by imparting technological inputs and managerial skills to become technocrats.	-	-

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES :

The course should enable the students to:	
I	Understand the laws of thermodynamics and determine thermodynamic properties, gas laws.
II	Knowledge of properties during various phases of pure substances, mixtures, usage of steam tables and Mollier chart, psychometric charts.
III	Understand the direction law and concept of increase in entropy of universe.
IV	Understand the working of ideal air standard, vapor cycles and evaluate their performance in open systems like steam power plants, internal combustion engines, gas turbines and refrigeration systems.

IX. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Describe the basic concepts and first law of thermodynamics.	CLO 1	Understand the concepts of conservation of mass, conservation of energy.
		CLO 2	Demonstrate knowledge of ability to identify & apply fundamentals to solve problems like system properties, amount of work transfer and heat during various processes.
		CLO 3	Explore knowledge & ability to design the thermal related components in various fields of energy transfer equipment.
		CLO 4	Derive the first law of Thermodynamics from the concept of conservation of energy
CO 2	Describe the second law of thermodynamics and understand the concept of entropy and third law of thermodynamics.	CLO 5	Discuss the nature of steady and unsteady processes under the influence of time.
		CLO 6	Determine entropy changes in a wide range of processes and determine the reversibility or irreversibility of a process from such calculations based on Carnot Cycle.
		CLO 7	Develop the second law of thermodynamics from the limitations of first law.
		CLO 8	Knowledge of the Gibbs and Helmholtz free energies as equilibrium criteria, and the statement of the equilibrium condition for closed and open systems.

COs	Course Outcome	CLOs	Course Learning Outcome
CO 3	Understand the Pure Substances various thermodynamic processes.	CLO 9	Discuss pressure-temperature, volume-temperature, pressure-volume phase diagrams and the steam tables in the analysis of engineering devices and systems.
		CLO 10	Understand the inter relationship between thermodynamic functions and an ability to use such relationships to solve practical problems.
		CLO 11	Understand the equation of state, specific and universal gas constants, throttling and free expansion processes.
		CLO 12	Discuss deviations from perfect gas model, Vander Waals equation of state.
CO 4	Understand the concept of Mixtures of perfect gases and psychometric properties,	CLO 13	Understand mole fraction, mass friction, gravimetric and volumetric analysis, volume fraction.
		CLO 14	Discuss dalton‘s law of partial pressure, Avogadro‘s laws of additive volumes, and partial pressure, equivalent gas constant.
		CLO 15	Understand enthalpy, specific heats and entropy of mixture of perfect gases.
		CLO 16	Understand the process of psychrometry that are used in the analysis of engineering devices like air conditioning systems.
CO 5	Develop the concept power cycle with escription and representation on P-V and T-S diagram.	CLO 17	Develop Otto, Diesel, Dual combustion cycles, description and representation on P-V and T-S diagram.
		CLO 18	Discuss thermal efficiency; mean effective pressures on air standard basis.
		CLO 19	Understand the comparison of various cycles.
		CLO 20	Understand introduction to Brayton cycle and Bell Coleman cycle.

X. COURSE LEARNING OUTCOMES (CLOs):

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
AMEB04.01	CLO 1	Understand the concepts of conservation of mass, conservation of energy.	PO 1	3
AMEB04.02	CLO 2	Demonstrate knowledge of ability to identify & apply fundamentals to solve problems like system properties, amount of work transfer and heat during various processes.	PO 2	2
AMEB04.03	CLO 3	Explore knowledge & ability to design the thermal related components in various fields of energy transfer equipment.	PO 1	3
AMEB04.04	CLO 4	Derive the first law of Thermodynamics from the concept of conservation of energy	PO 1	3
AMEB04.05	CLO 5	Discuss the nature of steady and unsteady processes under the influence of time.	PO 2	2
AMEB04.06	CLO 6	Determine entropy changes in a wide range of processes and determine the reversibility or irreversibility of a process from such calculations based on Carnot Cycle.	PO 2	2
AMEB04.07	CLO 7	Develop the second law of thermodynamics from the limitations of first law.	PO 1	3
AMEB04.08	CLO 8	Knowledge of the Gibbs and Helmholtz free energies as equilibrium criteria, and the statement of the equilibrium condition for closed and open systems.	PO 2	2
AMEB04.09	CLO 9	Discuss pressure-temperature, volume-temperature, pressure-volume phase diagrams and the steam tables in the analysis of engineering devices and systems.	PO 4	1
AMEB04.10	CLO 10	Understand the inter relationship between	PO 2	2

		thermodynamic functions and an ability to use such relationships to solve practical problems.		
AMEB04.11	CLO 11	Understand the equation of state, specific and universal gas constants, throttling and free expansion processes.	PO 2	2
AMEB04.12	CLO 12	Discuss deviations from perfect gas model, Vander Waals equation of state.	PO 1 PO 2	3
AMEB04.13	CLO 13	Understand mole fraction, mass friction, gravimetric and volumetric analysis, volume fraction.	PO 1	3
AMEB04.14	CLO 14	Discuss dalton's law of partial pressure, Avogadro's laws of additive volumes, and partial pressure, equivalent gas constant.	PO 1	3
AMEB04.15	CLO 15	Understand enthalpy, specific heats and entropy of mixture of perfect gases.	PO 1	3
AMEB04.16	CLO 16	Understand the process of psychrometry that are used in the analysis of engineering devices like air conditioning systems	PO 1, PO 2	3
AMEB04.17	CLO 17	Develop Otto, Diesel, Dual combustion cycles, description and representation on P-V and T-S diagram.	PO 1, PO 2	3
AMEB04.18	CLO 18	Discuss thermal efficiency; mean effective pressures on air standard basis.	PO 1, PO 2	3
AMEB04.19	CLO 19	Understand the comparison of various cycles.	PO 1	3
AMEB04.20	CLO 20	Understand introduction to Brayton cycle and Bell Coleman cycle.	PO 2	2

3= High; 2 = Medium; 1 = Low

XI. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES

Course Outcomes (COs)	Program Outcomes (POs)			
	PO 1	PO 2	PO 4	PSO1
CO 1	3	2		1
CO 2	3	2		
CO 3	3		1	
CO 4		2		1
CO 5	3	2		1

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XII. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Learning Outcomes (CLOs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 1	3												1		
CLO 2		2													
CLO 3	3												1		

Course Learning Outcomes (CLOs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 4	3												1		
CLO 5		2													
CLO 6		2													
CLO 7	3														
CLO 8		2													
CLO 9				1											
CLO 10		2													
CLO 11		2											1		
CLO 12	3	2											1		
CLO 13	3														
CLO 14	3														
CLO 15	3														
CLO 16	3	2											1		
CLO 17	3	2											1		
CLO 18	3	2											1		
CLO 19	3												1		
CLO 20		2											1		

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XIII. ASSESSMENT METHODOLOGIES – DIRECT

CIE Exams	PO1, PO2, PO4	SEE Exams	PO1, PO2, PO4	Assignments	-	Seminars	PO1, PO2, PO4
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	PO1, PO2, PO4						

XIV. ASSESSMENT METHODOLOGIES - INDIRECT

✔	Early Semester Feedback	✔	End Semester OBE Feedback
✘	Assessment of Mini Projects by Experts		

XV. SYLLABUS

Module-I	BASIC CONCEPTS AND FIRST LAW OF THERMODYNAMICS
System, control volume, surrounding, boundaries, universe, types of systems, macroscopic and microscopic viewpoints, concept of continuum, thermodynamic equilibrium, state, property, process, cycle, reversibility, quasi static process, irreversible process, causes of irreversibility, various flow and non-flow processes ,energy in state and in transition, types-work and heat, point and path function, Zeroth law of thermodynamics, concept of quality of temperature, Principles of thermometry, reference points,constant volume gas thermometer, ideal gas scale, PMMI Joule's experiments, first law of thermodynamics, corollaries first law applied to a process, applied to a flow system, steady flow energy equation.	
Module-II	**SECOND LAW OF THERMODYNAMICS**
Thermal reservoir, heat engine, heat pump, parameters of performance, second Law of thermodynamics, Kelvin Planck and Clausius statements and their equivalence, Corollaries, PMM of second kind, carnot's principle, Carnot cycle and its specialties, thermodynamic scale of temperature, Clausius inequality, Entropy, principle of Entropy increase, availability and irreversibility, thermodynamic potentials, Gibbs and Helmholtz functions, Maxwell relations, elementary treatment of the Third Law of thermodynamics	
Module-III	**PURE SUBSTANCES**
Phase transformations, T-S and H-S diagrams, P-V-T surfaces, triple point at critical state properties during change of phase, dryness fraction, Mollier charts, various thermodynamic processes and energy transfer, steam calorimeter. Equation of state, specific and universal gas constants, throttling and free expansion processes, deviations from perfect gas model, Vander Waals equation of state.	
Module-IV	**MIXTURES OF PERFECT GASES**
Mole fraction, mass friction, gravimetric and volumetric analysis, volume fraction, Dalton's law of partial pressure, Avogadro's laws of additive volumes, and partial pressure, equivalent gas constant, internal energy, enthalpy, specific heats and entropy of mixture of perfect gases; psychometric properties, dry bulb temperature, wet bulb temperature, dew point temperature, thermodynamic wet bulb temperature, specific humidity, relative humidity, saturated air, vapor pressure, degree of saturation, adiabatic saturation, Carrier's equation, Psychometric chart.	
Module-V	**AIR CONDITIONING SYSTEMS**
Otto, Diesel, Dual combustion cycles, description and representation on P-V and T-S diagram, thermal efficiency, mean effective pressures on air standard basis, comparison of cycles, introduction to Brayton cycle and Bell Coleman cycle.	
Text Books:	
1. P. K. Nag, "Engineering Thermodynamics", Tata McGraw Hill, 4th Edition, 2008. 2. Yunus Cengel, Michael A. Boles, "Thermodynamics-An Engineering Approach", Tata McGraw Hill, 7th Edition, 2011.	
Reference Books:	
1. J. B. Jones, R. E. Dugan, "Engineering Thermodynamics", Prentice Hall of India Learning, 1st Edition,2009. 2. Y. V. C. Rao, "An Introduction to Thermodynamics", Universities Press, 3rd Edition, 2013. 3. K. Ramakrishna, "Engineering Thermodynamics", Anuradha Publishers, 2nd Edition, 2011. 4. Holman. J.P, "Thermodynamics", Tata McGraw Hill, 4th Edition, 2013.	

XVI. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
1	System, control volume, surrounding, boundaries, universe, types of systems.	CLO 1	T2:2.3
2	Macroscopic and microscopic viewpoints, concept of continuum,	CLO 1	R1:2.6
3	Thermodynamic equilibrium, state, property, process, cycle, reversibility,	CLO 2	T1:2.6
4	Quasi static process, irreversible process, causes of irreversibility	CLO 2	T2:2.7 R1:2.18
5	Various flow and non-flow processes ,energy in state and in transition, types-work	CLO 3	T2:2.22
6	Heat, point and path function, Zeroth law of thermodynamics.	CLO 3	T2:2.25
7	Concept of quality of temperature, Principles of thermometry, reference points.	CLO 3	T2:2.26 R1:2.55
8	Constant volume gas thermometer, ideal gas scale, PMMI Joule‘s experiments,	CLO 4	T2:2.16 R1:2.61
9	First law of thermodynamics, corollaries first law applied to a process	CLO 4	T2:2.30 R1:2.58
10	Applied to a flow system, steady flow energy equation.	CLO 4	T2:3.6 R1:4.29
11	Thermal reservoir, heat engine, heat pump	CLO 5	T2:3.14 R1:4.31
12	Parameters of performance, second Law of thermodynamics	CLO 6	T2:3.14 R1:4.33
13	Kelvin Planck, Clausius statements and their equivalence	CLO 6	R1:4.36
14	Corollaries, PMM of second kind, Carnot‘s principle	CLO 6	T2:3.18 R1:4.64
15	Carnot cycle and its specialties	CLO 7	T2:3.22
16	thermodynamic scale of temperature, Clausius inequality	CLO 7	T2:3.28 R1:4.67
17	Entropy, principle of Entropy increase, availability and irreversibility	CLO 8	T2:4.2
18	Thermodynamic potentials	CLO 8	T2:4.3 R1:4.71
19	Gibbs and Helmholtz functions, Maxwell relations	CLO 8	T1:4.8 R2:4.68
20-21	Elementary treatment of the Third Law of thermodynamics	CLO 8	T2:4.15 R1:5.74
22	Phase transformations, T-S and H-S diagrams, P-V-T surfaces,	CLO 8	T1:4.12 R2:5.75
23-24	Triple point at critical state properties during change of phase,	CLO 9	T1:4.8 R1:5.72
25	Dryness fraction, Mollier charts, various thermodynamic processes	CLO 9	T1:5.8 R1:5.73
26-27	Energy transfer, steam calorimeter.	CLO 10	T1:5.14 R1:6.78
28	Equation of state, specific and universal gas constants.	CLO 10	T2:5.19 R1:6.81
29-30	Throttling and free expansion processes	CLO 11	T1:6.4 R2:6.8
31	Deviations from perfect gas model, Vander Waals equation of state.	CLO 11	T2:7.7 R1:7.74
32-33	Mole fraction, mass friction, gravimetric and volumetric analysis, volume fraction,	CLO 12	T1:7.12 R2:8.75

34	Dalton‘s law of partial pressure, Avogadro‘s laws of additive volumes, and partial pressure	CLO 13	T1:7.8 R1:8.72
35	Equivalent gas constant, internal energy, enthalpy, specific heats	CLO 14	T1:8.8 R1:8.73
36	Entropy of mixture of perfect gases; psychometric properties	CLO 15	T1:9.14 R1:10.78
37-38	Dry bulb temperature, wet bulb temperature, dew point temperature,	CLO 16	T2:9.19 R1:10.814
39-40	Thermodynamic wet bulb temperature, specific humidity, relative humidity, saturated air	CLO 17	T1:10.4 R2:11.68
41-43	Vapor pressure, degree of saturation, adiabatic aturation,Carrier‘s equation, Psychometric chart.	CLO 17	T2:10.7 R1:12.74
44-45	Otto, Diesel, Dual combustion cycles,	CLO 18	T1:11.12 R2:12.75
46-47	Description and representation on P-V and T-S diagram,	CLO 19	T1:12.4 R2:13.68
48-49	Thermal efficiency, mean effective pressures on air standard basis	CLO 19	T2:13.7 R1:14.74
50-52	Comparison of cycles, introduction to Brayton cycle and Bell Coleman cycle.	CLO 20	T1:14.12 R2:15.75

XVII. GAPS IN THE SYLLABUS-TO MEET INDUSTRY / PROFESSION REQUIREMENTS:

S NO	DESCRIPTION	PROPOSED ACTIONS	RELEVANCE WITH POs	RELEVANCE WITH PSOs
1	To improve standards and analyze the concepts.	Seminars	PO 1	PSO 1
2	To understand the technology of thermo-electric refrigeration, solar powered refrigeration, etc.	Seminars / NPTEL	PO 4	PSO 1
3	Encourage students to solve real time applications and prepare towards competitive examinations.	NPTEL	PO 2	PSO 1

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