INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad -500 043

AERONAUTICAL ENGINEERING

COURSE DESCRIPTOR

Course Title	**THERMODYNAMICS**				
Course Code	AME003				
Programme	B.Tech				
Semester	IV	AE			
Course Type	Core				
Regulation	IARE - R16				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	-	-
Chief Coordinator	Ms. Ch Ragha Leena, Assistant Professor				
Course Faculty	Ms. Ch. Ragha Leena, Assistant Professor Mr. R.Sabari Vihar, 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
-	-	-	Basic concepts of Mathematics and Physics

III. MARKSDISTRIBUTION:

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 units and each unit 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 unit. 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 25 marks for Continuous Internal Examination (CIE), 05 marks for Quiz/ Alternative Assessment Tool (AAT).

Table 1: Assessment pattern for CIA

Component	**Theory**		**Total Marks**
Type of Assessment	CIE Exam	Quiz / AAT	
CIA Marks	10	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 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five 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 / Alternative Assessment Tool (AAT):
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are be answered by choosing the correct answer from a given set of choices (commonly four). Marks shall be awarded considering the average of two quizzes for every course. The AAT may include seminars, assignments, term paper, open ended experiments, five minutes video and MOOCs.

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	Assignments
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	3	Real time applications
PO 3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	2	Videos

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:** Able to utilize the knowledge of aeronautical/aerospace engineering in innovative, dynamic and challenging environment for design and development of new products	2	Assignments
PSO2	**Problem-solving Skills:** Imparted through simulation language skills and general purpose CAE packages to solve practical, design and analysis problems of components to complete the challenge of airworthiness for flight vehicles.	**-**	**-**
PSO 3	**Practical implementation and testing skills:** Providing different types of in house and training and industry practice to fabricate and test and develop the products with more innovative technologies	-	-
PSO 4	**Successful career and entrepreneurship:** To prepare the students with broad aerospace knowledge to design and develop systems and subsystems of aeronautical/aerospace allied systems to become technocrats.	-	-

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES (COs):

The course should enable the students to:	
I	Understand the laws of thermodynamics and determine thermodynamic properties, gas laws.
II	Apply 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 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
AME003.01	CLO 1	Understand various forms of energy, mechanisms of energy transfer, the concept of energy transfer, the concept of temperature, energy balance, energy conservation and conversion efficiency using familiar processes that involver mostly mechanical forms of energy.	PO 1	3
AME003.02	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 1 PO 2	3
AME003.03	CLO 3	Explore knowledge & ability to design the thermal related components in various fields of energy transfer equipment.	PO 1 PO 3	3
AME003.04	CLO 4	Derive the first law of Thermodynamics from the concept of conservation of energy	PO 1	3
AME003.05	CLO 5	Discuss the nature of steady and unsteady processes under the influence of time	PO 1	3
AME003.06	CLO 6	Develop the second law of thermodynamics from the limitations of first law.	PO 1	2
AME003.07	CLO 7	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 1 PO 2	3
AME003.08	CLO 8	Understand the inter relationship between thermodynamic functions and an ability to use such relationships to solve practical problems	PO 3	2
AME003.09	CLO 9	Knowledge of the Gibbs and Helmholtz free energies as equilibrium criteria, and the statement of the equilibrium condition for closed and open systems	PO 1	2
AME003.10	CLO 10	Determine the equilibrium states of a wide range of systems, ranging from mixtures of gases, liquids, solids and pure condensed phases that can each include multiple components.	PO 2	3
AME003.11	CLO 11	Discuss pressure-temperature, volume-temperature, pressure-volume phase diagrams and the steam tables in the analysis of engineering devices and systems.	PO 2	3
AME003.12	CLO 12	Develop the Third Law of Thermodynamics from the concept of absolute thermodynamic scale and describe its significance.	PO 1	3
AME003.13	CLO 13	Understand the process of psychrometry that are used in the analysis of engineering devices like air conditioning systems	PO 3	2
AME003.14	CLO 14	Introduction to concepts of power and refrigeration cycles. Their efficiency and coefficients of performance.	PO 2 PO 3	3
AME003.15	CLO 15	Ability to use modern engineering tools,	PO 3	2

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
		software and equipment to analyze energy transfer in required air-condition application.		
AME003.16	CLO 16	Explore the use of modern engineering tools, software and equipment to prepare for competitive exams, higher studies etc.	PO 3	2

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X. 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	PSO4
CLO 1	3												2			
CLO 2	3	3											1			
CLO 3	3		2										2			
CLO 4	3												2			
CLO 5	3												2			
CLO 6	3												2			
CLO 7	3	3											2			
CLO 8			2													
CLO 9	3												2			
CLO 10		3														
CLO 11		3														
CLO 12	3												2			
CLO 13		3														
CLO 14		3	2													
CLO 15			2													
CLO 16			2													

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XI. ASSESSMENT METHODOLOGIES–DIRECT

CIE Exams	PO 1, PO 2, PO 3	SEE Exams	PO 1, PO 2, PO 3	Assignments	PO 1, PO 2	Seminars	PO 1
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	-						

XII. ASSESSMENT METHODOLOGIES-INDIRECT

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

XIII. SYLLABUS

Unit-I	BASIC CONCEPTS AND FIRST LAW OF THERMODYNAMICS
Basic Concepts: 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.	
Unit-II	**SECOND LAW OF THERMODYNAMICS**
Limitations of the first law: 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.	
Unit-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. Perfect Gas Laws: Equation of State, Specific and Universal Gas constants, Throttling and Free Expansion Processes, Deviations from perfect Gas Model, Vander Waals Equation of State.	
Unit-IV	**MIXTURE 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, sp. Heats and Entropy of Mixture of perfect Gases . Psychrometric properties-Dry bulb temperature, wet bulb temperature, specific humidity, Relative humidity, saturated air, Degree of saturation-adiabatic saturation, carrier equation, psychrometric chart.	
Unit-V	**POWER CYCLES**
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 Publishers, 5th Edition, 2013. 2. Yunus Cengel, Michael A. Boles, "Thermodynamics-An Engineering Approach", Tata McGraw Hill publishers, 8th Edition, 2014.	
Reference Books:	
1. J. B. Jones, R. E. Dugan, "Engineering Thermodynamics", Prentice Hall of India Learning. 2. Y. V. C. Rao, "An Introduction to Thermodynamics", Universities Press. 3. K. Ramakrishna, "Engineering Thermodynamics", Anuradha Publishers. 4. J.P Holman, "Thermodynamics" Tata McGraw Hill Publishers.	

XIV. 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	Basics concepts of Thermodynamics: Surrounding, Boundaries, Universe, Types of Systems, properties	CLO 1	T1:1.7 T2:1-3
2	Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic Equilibrium	CLO 2	T1:1.13 T2:1-4
3	State, Property, Process, Cycle, Reversibility, Quasi static Process, Irreversible Process, Causes of Irreversibility	CLO 1	T1:1.11 T2:1-3
4	Various flow and non-flow processes	CLO 1	T1:5.6 T2:2-5
5	Energy in State and in Transition, Types-Work and Heat, Point and Path function	CLO 2	T1:3.2 T2:2-4
6	Zeroth Law of Thermodynamics, Concept of quality of Temperature, Principles of Thermometry, Reference Points	CLO 3	T1:2.1 T2:1-8
7	Constant Volume gas Thermometer, Ideal Gas Scale, PMMI	CLO 1	T1:2.5 T2:1-8
8	Joule's Experiments, First law of Thermodynamics, Corollaries First law applied to a Process	CLO 4	T1:3.6 T2:2-6
9-10	Applied to a flow system, Steady Flow Energy Equation	CLO 5	T1:5.3 T2:2-6
11	Thermal Reservoir, Heat Engine, Heat pump, Parameters of performance	CLO 6	T1:6.3 T2:6-1
12	Second Law of Thermodynamics, Kelvin Planck Statement	CLO 6	T1:6.4 T2:6-4
13-14	Clausius Statements and their Equivalence / Corollaries, PMM of Second kind, Carnot's principle	CLO 7	T1:6.5 T2:6-5
15-16	Carnot cycle and its specialties, Thermodynamic scale of Temperature, Clausius Inequality	CLO 7	T1:6.11 T2:6-6
17-19	Entropy, Principle of Entropy Increase, Availability and Irreversibility, Thermodynamic Potentials, Gibbs and Helmholtz Functions	CLO 9	T1:6.9 T2:7-2
20-22	Maxwell Relations, Elementary Treatment of the third Law of Thermodynamics	CLO 12	T1:11.2 T2:12-2
23-24	Pure Substances: Phase Transformations, T-S and H-S diagrams, P-V-T- Surfaces	CLO 11	T1:9.2 T2:3-4
24-25	T-S And H-S diagrams, P-V-T- Surfaces	CLO 11	T1:9.4 T2:3-4
26	Triple Point At Critical State Properties During Change Of Phase	CLO 10	T1:9.5 T2:1-3
27-28	Dryness Fraction, Mollier Charts, Problems	CLO 10	T1:9.5 T2:1-3
29-30	Various Thermodynamic Processes And Energy Transfer, Steam Calorimeter, Problems	CLO 02	T1:9.6
31-32	Perfect Gas Laws: Equation Of State	CLO 10	T1:10.2 T2:13-1
33	Specific and Universal Gas Constants	CLO 10	T1:10.3 T2:13-1
34-35	Throttling and Free Expansion Processes	CLO 10	T1:10.5 T2:13-2
36	Deviations from Perfect Gas Model	CLO 11	T1:10.6 T2:13-3
37-39	Vander Waals Equation of State	CLO 11	T1:10.4
40-41	Mixtures of Perfect Gases: Mole Fraction, Mass Friction	CLO 10	T1:10.8 T2:13-3

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
42	Gravimetric And Volumetric Analysis, Volume Fraction, Problems	CLO 10	T1:10.8 T2:13-2
43-44	Dalton's Law of Partial Pressure	CLO 10	T1:10.8 T2:13-2
45-46	Avogadro's Laws of Additive Volumes and Partial Pressure	CLO 11	T1:10.7 T2:13-3
47	Equivalent Gas Constant, Internal Energy, Enthalpy	CLO 10	T1:10.9 T2:13-1
48-49	Sp. Heats And Entropy of Mixture of Perfect Gases, Problems	CLO 08	T1:10.9 T2:13-2
50-51	Psychrometric Properties-Dry Bulb Temperature, Wet Bulb Temperature	CLO 13	T1:15.1 T2:14-1
52	Specific Humidity, Relative Humidity	CLO 12	T1:15.2 T2:14-2
53	Saturated Air, Degree of Saturation-Adiabatic Saturation	CLO 12	T1:15.2 T2:14-4
54	Carrier Equation, Psychrometric Chart	CLO 13	T1:15.3 T2:14-5
55-56	Power Cycles: Otto Cycle	CLO 14	T1:13.6 T2:9-5
57	Diesel, Dual Combustion Cycles	CLO 14	T1:13.6 T2:9-6
58	Description and Representation on P-V And T-S Diagram	CLO 14	T1:13.8 T2:9-5
59-60	Thermal Efficiency, Mean Effective Pressures on Air Standard Basis	CLO 14	T1:13.8 T2:9-6
61	Comparison of Cycles	CLO 14	T1:13.9 T2:9-5
62	Introduction to Brayton Cycle And Bell Coleman Cycle	CLO 14	T1:13.12 T2:9-8

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

S No	Description	Proposed actions	Relevance with POs	Relevance with PSOs
1	Directional law applied to automobile sector	Guest Lecture/Seminar	PO1,PO2,PO4	PSO 2
2	Gas laws applied to cooling of electronic chips	Seminars	PO 5	PSO 2, PSO 3
3	Cooling of spindle bearings by using chillers	Seminars	PO 3	PSO 1, PSO 3

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