INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad -500 043

AERONAUTICAL ENGINEERING

COURSE DESCRIPTOR

Course Title	**ENGINEERING THERMODYNAMICS**				
Course Code	AAEB02				
Programme	B.Tech				
Semester	III	AE			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	-	3	-	-
Chief Coordinator	Mr. R.SabariVihar, Assistant Professor				
Course Faculty	Mrs.Madhurakavi Shravani, Assistant Professor Mr. R.SabariVihar, 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 along with applications of power cycles.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AHSB03	II	Engineering Chemistry	4

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 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 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 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 quizzes for every course.

Alternative Assessment Tool (AAT)

This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the class room into 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 and 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	Seminars
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	Assignments
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	Seminars

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	Seminars
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.	2	Assignments
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	-	-
PSO4	**Successful career and entrepreneurship:** To prepare the students with broad aerospace knowledge to design and develop systems and subsystems of aerospace and allied systems and 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	Apply knowledge of pure substances, mixtures, usage of steam tables and Mollier chart, psychrometric charts.
III	Understand the direction law and concept of increase in entropy of universe.
IV	Understand the working of ideal air standard, vapour cycles and evaluate their performance in open systems like steam power plants, internal combustion engines, gas turbines and refrigeration systems.
V	Understand the basic concepts of heat transfer and working and types of heat exchangers.

IX. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Understand basics of thermodynamics along with basic laws of thermodynamics.	CLO 1	Understand the basic terms and terminologies of thermodynamics along with different view point of thermodynamic systems.
		CLO 2	Get knowledge about concept of temperature and explain zeroth law of thermodynamics and also about quality of temperature.
		CLO 3	Explain about first law of thermodynamics and its various corollaries along with Joules experiment.
CO 2	Understand the limitations of first law of thermodynamics and different forms of second law of thermodynamics.	CLO 4	Understand the limitations of first law of thermodynamics.
		CLO 5	Explain about thermal reservoir, heat pump, heat engine and parameters of performance.
		CLO 6	Explain second law of thermodynamics, Kelvin planck and Clausius statement of it.
		CLO 7	Understand the Kelvin planck and Clausius equivalence, corollaries and understand about perpetual motion machine one.
CO 3	Describe the properties of pure substances with help of phase diagrams and also understand the psychrometric properties.	CLO 8	Understand the term entropy, its principle and how it influences the availability and irreversibility of thermodynamic potentials.
		CLO 9	Understand pure substances and phase diagrams and about terms triple point and critical point.
		CLO 10	Understand how properties like wet bulb temperature, dry bulb temperature, dew bulb temperature help in building mollier chart and psychrometric chart.
		CLO 11	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.
CO 4	Understand different processes in different standard cycles and calculate efficiencies of each cycle.	CLO 12	Introduction to concepts of power and refrigeration cycles. Their efficiency and coefficients of performance.
		CLO 13	Ability to use modern engineering tools, software and equipment to analyze energy transfer in required air-condition application.
		CLO 14	Explore the use of modern engineering tools, software and equipment to prepare for competitive exams, higher studies etc.
CO 5	Understand working of heat exchangers, different types	CLO 15	Understand about working of heat exchangers and different types of heat exchangers.

COs	Course Outcome	CLOs	Course Learning Outcome
	of heat exchangers and working of them.	CLO 16	Understand the working of gas compressors and air compressors and different types of air compressors.

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
AAEB02.01	CLO 1	Understand the basic terms and terminologies of thermodynamics along with different view point of thermodynamic systems.	PO 1	3
AAEB02.02	CLO 2	Get knowledge about concept of temperature and explain zeroth law of thermodynamics and also about quality of temperature.	PO 2	2
AAEB02.03	CLO 3	Explain about first law of thermodynamics and its various corollaries along with Joules experiment.	PO 1	3
AAEB02.04	CLO 4	Understand the limitations of first law of thermodynamics.	PO 1	3
AAEB02.05	CLO 5	Explain about thermal reservoir, heat pump, heat engine and parameters of performance.	PO 2	2
AAEB02.06	CLO 6	Explain second law of thermodynamics, Kelvin planck and Clausius statement of it.	PO 2	2
AAEB02.07	CLO 7	Understand the Kelvin planck and Clausius equivalence, corollaries and understand about perpetual motion machine one.	PO 2	2
AAEB02.08	CLO 8	Understand the term entropy, its principle and how it influences the availability and irreversibility of thermodynamic potentials.	PO 2	2
AAEB02.09	CLO 9	Understand pure substances and phase diagrams and about terms triple point and critical point.	PO 4	1
AAEB02.10	CLO 10	Understand how properties like wet bulb temperature, dry bulb temperature, dew bulb temperature help in building mollier chart and psychrometric chart.	PO 4	1
AAEB02.11	CLO 11	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	2
AAEB02.12	CLO 12	Introduction to concepts of power and refrigeration cycles. Their efficiency and coefficients of performance.	PO 2	2
AAEB02.13	CLO 13	Ability to use modern engineering tools, software and equipment to analyze energy transfer in required air-condition application.	PO 1	3
AAEB02.14	CLO 14	Explore the use of modern engineering tools, software and equipment to prepare for competitive exams, higher studies etc.	PO 1	3
AAEB02.15	CLO 15	Understand about working of heat exchangers and different types of heat exchangers.	PO 1	3
AAEB02.16	CLO 16	Understand the working of gas compressors and air compressors and different types of air compressors.	PO 2	3

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

Course Outcomes (COs)	Program Outcomes (POs)			Program Specific Outcomes (PSOs)	
	PO 1	PO 2	PO 4	PSO1	PSO2
CO 1	3	2		2	2
CO 2	3	2			2
CO 3		2	1	2	2
CO 4	3	2		2	
CO 5	3	3		2	

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

3 = High; 2 = Medium; 1 = Low

XIII. ASSESSMENT METHODOLOGIES–DIRECT

CIE Exams	PO 1, PO 2, PO 4, PSO 1, PSO 2	SEE Exams	PO 1, PO 2, PO 4, PSO 1, PSO 2	Assignments	PO 2, PSO 2	Seminars	PO 1, PO 4, PSO 1
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	-						

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**
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.	
Module -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, Third Law of thermodynamics.	
Module -III	**PURE SUBSTANCES AND MIXTURES OF PERFECT GASES**
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, psychometric properties, dry bulb temperature, wet bulb temperature, dew point temperature, thermodynamic wet bulb temperature, specific humidity, relative humidity, saturated air, vapour pressure, degree of saturation, adiabatic saturation, Carrier's equation, Psychometric chart.	
Module -IV	**POWER CYCLES**
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.	
Module-V	**ELEMENTS OF HEAT TRANSFER AND GAS COMPRESSORS**
Basic concepts of Heat Transfer: Conduction, Convection and Radiation, Heat Exchangers, Types of Heat Exchangers. Basic concepts of: Gas Compressors, Air Compressors, Single-Stage Reciprocating Air Compressor, Multi-Stage Compression, Volumetric Efficiency, Air Motors,	

Rotary Compressors
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.

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
1-3	Basics concepts of Thermodynamics: Surrounding, Boundaries, Universe, Types of Systems, properties	CLO 1	T1:1.1
4	Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic Equilibrium	CLO 1	T1:1.5, R2: 1.3
5	State, Property, Process, Cycle, Reversibility, Quasi static Process, Irreversible Process, Causes of Irreversibility	CLO 2	T1:1.6 R2: 1.39
6	Various flow and non-flow processes	CLO 2	T1:1.7
7	Energy in State and in Transition, Types-Work and Heat, Point and Path function	CLO 2	T1:1.8, R2: 1.63
8-9	Zeroth Law of Thermodynamics, Concept of quality of Temperature, Principles of Thermometry, Reference Points	CLO 3	T1:2.1, R2: 1.72
10	Constant Volume gas Thermometer, Ideal Gas Scale, PMMI	CLO 3	T1:2.3
11	Joule's Experiments, First law of Thermodynamics, Corollaries First law applied to a Process	CLO 4	T1:2.4, R2: 2.13
12	Applied to a flow system, Steady Flow Energy Equation	CLO 4	T1:2.5
13	Thermal Reservoir, Heat Engine, Heat pump, Parameters of performance	CLO 5	T1: 6.3, R2: 2.19
14	Second Law of Thermodynamics, Kelvin Planck Statement	CLO 5	T1:6.7
15-16	Clausius Statements and their Equivalence / Corollaries,	CLO 6	T1:6.5
17-18	PMM of Second kind, Carnot's principle	CLO 6	T1:6.11
19	Carnot cycle and its specialties, Thermodynamic scale of Temperature, Clausius Inequality	CLO 7	T1:7.6, R2: 2.23
20-22	Entropy, Principle of Entropy Increase, Availability and Irreversibility,	CLO 8	T1:8.8, R2: 2.26
23-24	Thermodynamic Potentials, Gibbs and Helmholtz Functions Maxwell Relations,	CLO 8	T1:11.2, R2: 2.32
24-26	Elementary Treatment of the third Law of Thermodynamics	CLO 8	T1:13.2
27	Pure Substances: Phase Transformations, T-S and H-S diagrams, P-V-T- Surfaces T-S And H-S diagrams, P-V-T-Surfaces	CLO 9	T1:9.4, R2: 3.2
28-30	Triple Point At Critical State Properties During Change Of Phase	CLO 9	T1: 10.11, R2: 3.31
30	Dryness Fraction, Mollier Charts, Problems	CLO 9	T1: 11.2
31-32	psychometric properties, psychrometric charts	CLO 9	T1:15.2
33	Dry bulb temperature, wet bulb temperature, dew point temperature, thermodynamic wet bulb temperature,	CLO 10	T1:10.3

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
34-35	specific humidity, relative humidity, saturated air, vapour pressure	CLO 10	T1:10.5
36	degree of saturation, adiabatic saturation,	CLO 11	T1:10.6
37-39	Carrier's equation	CLO 11	T1:10.4
40-41	Otto, Diesel, Dual combustion cycles description and	CLO 12	T1:13.5, R2: 8.1
42-44	representation on P-V and T-S diagram	CLO 12	T1:13.7 R2: 8.3
45-47	thermal efficiency, mean effective pressures on air standard basis, comparison of cycles.	CLO 13	T1:13.8, R2: 8.15
48-50	Introduction to Brayton cycle and Bell Coleman cycle.	CLO 13	T1:13.9
50	Basic concepts of Heat Transfer: Conduction, Convection and radiation	CLO 14	T1:18.1
51-52	Heat Exchangers, Types of Heat Exchangers	CLO 14	T1:18.4
53-54	Basic concepts of Gas Compressors	CLO 15	T2: 16.4
55	Basic concepts of Air Compressors,	CLO 15	T2:17.2
56	Single-Stage Reciprocating Air Compressor	CLO 15	T2:17-4
57-58	Multi-Stage Compression	CLO 16	T2:17.9
59	Volumetric Efficiency, Air Motors	CLO 16	T2: 17.13
60	Rotary Compressors	CLO 16	T2 : 17.18

XVII. 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/Semiar	PO1,PO2	PSO 2
2	Cooling of spindle bearings by using chillers	Seminars	PO 4	PSO 1

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