INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad -500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTOR

Course Title	**APPILIED THERMODYNAMICS-I**				
Course Code	AMEB09				
Programme	B.Tech				
Semester	IV	ME			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	-	-
Chief Coordinator	Mr. G. Aravind Reddy, Assistant Professor , ME				
Course Faculty	Mr. G. Aravind Reddy, Assistant Professor , ME				

I. COURSE OVERVIEW:

Applied Thermodynamics is intended to introduce basic principles of internal combustion engines, compressors and refrigeration are widely used in automobile, agriculture, industry for transport, water pumping, electricity generation, earth moving and to supply mechanical power to grinders, crushers etc. Compressors are used for supply of gases including air at higher pressure. Compressors are used to supply compressed air to all pneumatic equipments and for gases such as cooking gas, oxygen, nitrogen, neon, argon compressors are also used. Thus there is great relevance for this course for mechanical engineers. Vapour compression refrigeration cycle based on thermodynamic system is studied.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AMEB04	III	Thermodynamics	4

III. MARKSDISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Applied 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**: Capability to apply the knowledge of mathematics, science and engineering and Mechanical Engineering principles related to combustion engines.	3	Presentation on Real-world problems
PO 2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using Thermodynamics concepts and principles.	2	Seminar
PO 3	**Design/ development of solutions:** Design, implement, and evaluate a Mechanical Engineering component, to meet desired needs within realistic constraints	1	Assignments
PO 6	**The engineer and society**: Maintaining the engineering practices such as time, efficiency, as well as appropriate constraints related to economic, environmental, ethical, health and safety, manufacturability, and sustainability considerations	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:** To produce engineering professional capable of synthesizing and analyzing mechanical systems including allied engineering streams.	1	Seminar
PSO 2	**Problem-Solving Skills:** 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 (COs):

The course should enable the students to:	
I	Understand the construction and working of internal combustion engines, compressors and refrigeration systems.
II	Develop the concept of ideal and real working of thermodynamic cycles for performance evaluation.
III	Understand the subsystems of internal combustion systems.

IX. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Understand the working related to 2S & 4S and injection systems for SI and CI engines	CLO 1	Understand main idea and importance behind the 2- S and 4-S IC engines
		CLO 2	Analyze the working of the basic components in the IC engine
		CLO 3	Understand the combustion process and also how it does affect the performance of the IC engines.
CO 2	Explore the concept on working of combustion in SI and CI engines	CLO 4	Apply the thermodynamic principles in the design of an IC engines
		CLO 5	Formulate and perform the procedures required for the maintenance and operation of IC engine
		CLO 6	Compare different IC engines and develop a system which meets the requirement
CO 3	Classification of various testing performance balance sheet and compressors	CLO 7	Knowledge of Fuel Requirements and Fuel Rating.
		CLO 8	Testing and Performance of I.C Engines.
		CLO 9	Analyze the working of the basic components in the Compressors and Refrigeration systems.
CO 4	Understand the concept related to rotary dynamic and axial compressors	CLO 10	Apply the thermodynamic principles in the design of Compressors and refrigeration system
		CLO 11	Formulate and perform the procedures required for the maintenance and operation of compressors and refrigeration systems.
		CLO 12	Compare different compressors and refrigeration systems and develop a system which meets the requirements.
CO 5	Understand the working related to Mechanical refrigeration, COP, refrigerants and use of p-h charts.	CLO 13	Understand the process of pressure enthalpy charts that are used in the Refrigeration systems.
		CLO 14	Introduction to concepts of power and refrigeration cycles. Their efficiency and coefficients of performance.
		CLO 15	Ability to use modern engineering tools, software and equipment to analyze energy transfer in required air-condition application.
		CLO 16	Explore the use of modern engineering tools, software and equipment to prepare for competitive exams, higher studies etc.

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
AMEB09.01	CLO 1	Understand main idea and importance behind the 2-S and 4-S IC engines	PO 1	3
AMEB09.02	CLO 2	Analyze the working of the basic components in the IC engine	PO 1	3
AMEB09.03	CLO 3	Understand the combustion process and also how it does affect the performance of the IC engines.	PO 1,PO 2	3
AMEB09.04	CLO 4	Apply the thermodynamic principles in the design of an IC engines	PO 1,PO 2	2
AMEB09.05	CLO 5	Formulate and perform the procedures required	PO 2	2

		for the maintenance and operation of IC engine		
AMEB09.06	CLO 6	Compare different IC engines and develop a system which meets the requirement	PO 1,PO 2,PO 3	2
AMEB09.07	CLO 7	Knowledge of Fuel Requirements and Fuel Rating.	PO 2	1
AMEB09.08	CLO 8	Testing and Performance of I.C Engines.	PO 2, PO 3	1
AMEB09.09	CLO 9	Analyze the working of the basic components in the Compressors and Refrigeration systems.	PO 2	2
AMEB09.10	CLO 10	Apply the thermodynamic principles in the design of Compressors and refrigeration system	PO 1,PO 2	2
AMEB09.11	CLO 11	Formulate and perform the procedures required for the maintenance and operation of compressors and refrigeration systems.	PO 1,PO 2,PO 3	3
AMEB09.12	CLO 12	Compare different compressors and refrigeration systems and develop a system which meets the requirements.	PO 3, PO 6	3
AMEB09.13	CLO 13	Understand the process of pressure enthalpy charts that are used in the Refrigeration systems.	PO 2, PO 6	3
AMEB09.14	CLO 14	Introduction to concepts of power and refrigeration cycles. Their efficiency and coefficients of performance.	PO 3,PO 2	3
AMEB09.15	CLO 15	Ability to use modern engineering tools, software and equipment to analyze energy transfer in required air-condition application.	PO 3, PO 6	1
AMEB09.16	CLO 16	Explore the use of modern engineering tools, software and equipment to prepare for competitive exams, higher studies etc.	PO 6	1

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

Course Outcomes (COs)	Program Outcomes (POs)				
	PO 1	PO 2	PO 3	PO 6	PSO 1
CO 1	3	2			1
CO 2	3	2	1		1
CO 3		2	1		
CO 4	3	2	1	1	1
CO 5		2	1	1	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	3												1		
CLO 3	3	2											1		
CLO 4	3	2													
CLO 5		2													
CLO 6	3	2	1												
CLO 7		2													
CLO 8		2	1												
CLO 9		2											1		
CLO 10	3	2											1		
CLO 11	3	2	1												
CLO 12			1			1									
CLO 13		3				1									
CLO 14		3	1										1		
CLO 15			1			1									
CLO 16						1									

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XIII. ASSESSMENT METHODOLOGIES–DIRECT

CIE Exams	PO1,PO2 PO3,PO6 PSO 1	SEE Exams	PO1,PO2, PO3,PO6, PSO 1	Assignments	PO 2,PSO 1	Seminars	PO 2, PSO 1
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	PO 3						

XIV. ASSESSMENT METHODOLOGIES-INDIRECT

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

XV. SYLLABUS

MODULE-I	IC ENGINES,FUEL INJECTION AND LUBRICATION SYSTEMS
I. C Engines: Four and two stroke engine, SI and CI engines, valve and port timing diagrams, fuel injection systems for SI engines, fuel injection systems for CI engines, ignition systems, cooling and lubrication system, fuel properties and combustion, stoichiometry.	
MODULE-II	**COMBUSTION IN SI AND CI ENGINES**
Combustion in SI engines and CI engines: Normal combustion and abnormal combustion, importance of flame speed and effect of engine variables, type of abnormal combustion, pre-ignition and knocking, fuel requirements and fuel rating, anti-knock additives, combustion chamber, requirements, types; Combustion in CI Engines: Four stages of combustion, delay period and its importance, effect of engine variables, diesel Knock, need for air movement, open and divided combustion chambers and nozzles used, fuel requirements and fuel rating	
MODULE-III	**TESTING AND PERFORMANCE,COMPRESSORS**
Testing and performance: Parameters of performance, measurement of cylinder pressure, fuel consumption, air intake, exhaust gas composition, brake power, determination of frictional losses and indicated power, performance test, heat balance sheet. and chart. Compressors: Classification, of compressors, fans, blower and compressor, positive displacement and dynamic types, reciprocating and rotary types.	
MODULE-IV	**ROTARY AND AXIAL CENTRIFUGAL COMPRESSORS**
Rotary, dynamic and axial flow (positive displacement): Roots blower, vane sealed compressor, mechanical details and principle of working efficiency considerations; Centrifugal compressors: mechanical details and principle of operation, velocity and Pressure variation, Energy transfer, impeller blade shape-losses, slip factor, and power input factor, pressure coefficient and adiabatic coefficient, velocity diagrams, power; Axial flow compressors: Mechanical details and principle of operation, velocity triangles and energy transfer per stage degree of reaction, work done factor, isentropic efficiency, pressure rise calculations, polytropic efficiency.	
MODULE-V	**REFRIGERATION**
Refrigeration: Mechanical refrigeration and types, units of refrigeration, air refrigeration system, details and principle of operation, applications of air refrigeration, vapour compression refrigeration systems, calculation of COP, effect of superheating and sub cooling, desired properties of refrigerants and common refrigerants, vapour absorption system, mechanical details, working principle, use of p-h charts for calculations.	
Text Books:	
1. V. Ganesan, "I.C. Engines", Tata McGraw-Hill, 3rd Edition, 2011 2. B. John Heywood, "Internal Combustion Engine Fundamentals", Tata McGraw-Hill, 2nd Edition,2011. 3. K. Rajput, "Thermal Engineering", Lakshmi Publications, 1st Edition, 2011.	
Reference Books:	
1.Mathur, Sharma, "IC Engines", DhanpatRai& Sons, 3rd Edition, 2008. 2. Pulkrabek, "Engineering Fundamentals of IC Engines", Pearson Education, 2nd Edition, 2008. 3. Rudramoorthy, "Thermal Engineering", Tata McGraw-Hill, 5th Edition 2003. 4. C. P. Arora, "Refrigeration and Air Conditioning", Tata McGraw-Hill Education, 3rdEdition, 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
1-2	Define Heat engine and classify IC Engines	CLO 1	T1:28.7 R1:2.6

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
3	Discuss working of SI and CI engines	CLO 2	T1:27.5 R1:2.7
4-6	Illustrate crank angle valve and port diagrams	CLO 2	T1:29.6 R1:2.6
7-8	Explain carburetor. Fuel supply for SI engine	CLO 7	T1:29.7 R1:4.4
9-10	Explain different Fuel injection systems for CI engines	CLO 4	T1:30.7 R1:4.10
11	Discuss Ignition system	CLO 6	T1:30.8 R1:4.25
12-13	Explain Cooling and Lubrication system	CLO 2	T1:22.9 R1:5.4
14	Illustrate different fuels and its properties with their stoichiometry.	CLO 7	T1:31.2 R1:5.8
15	Discuss phenomena of combustion process	CLO 3	T2:31.10 R1:6.8
16	Emphasize Normal and abnormal combustion phenomena.	CLO 6	T2:32.10 R1:6.13
17-18	Discuss Importance of flame speed and its effect on engine variables	CLO 8	T2:33.9 R1:7.5
21-22	Demonstrate Knocking and its additives	CLO 8	T2:34.10 R2:7.5
23-24	Illustrate different types of combustion chambers	CLO 6	T2:35.10 R3:8.1
25-26	Explain Four stages of combustion inC.I. Engines. Discuss delay period	CLO 6	T2:35.12 R1:9.2
27	Discuss knocking and its effect on engine variables.	CLO 8	T2:36.1 R2:9.4
28	What is the need for air movement and discuss different combustion chambers.	CLO 5	T2:37.1 R2:9.9
29	What are the fuel requirements	CLO 7	T1:23.1 R1:9.10
30	Definition of performance characteristics.	CLO 8	T2:27.5 R1:10.2
31-32	Determination of frictional power, efficiency, brakes power.	CLO 8	T2:27.7 R1:11.3
33-34	Discuss sankey diagram for heat balance sheet by means of losses.	CLO 8	T2:27.8 R1:11.6
35-37	Performance analysis of IC engines.	CLO 6	T2:27.12 R1:11.7
38	Classify compressors	CLO 9	T2:27.12 R1:11.8
39-40	Discuss different types of compressors.	CLO 11	T2:27.12 R1:11.9
41-43	Explain the working of roots blower vane sealed compressor and its mechanisms.	CLO 10	T2:27.12 R1:11.10
44	Mechanism details of centrifugal compressors.	CLO 12	T3:27.14 R1:12.3
45	Define power input factor, pressure coefficient and adiabatic coefficient	CLO 12	T3:27.1 R1:12.7
46	Draw velocity diagrams and find power	CLO 13	T3:27.17 R1:12.15

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
47-48	Discuss working principle of Axial flow compressor and find the efficiency.	CLO 11	T3:27.18 R1:12.19
49-50	Define work done factor, isentropic efficiency.	CLO 12	T3:27.19 R4:14.4
51-52	Define pressure rise calculations polytropic efficiency	CLO 13	T3:27.19 R4:14.5
53-54	Define refrigerating effect and its principle of operation.	CLO 13	T2:27.18 R4:12.19
55	Explain Air refrigeration system	CLO 13	T2:27.18 R4:12.19
56-57	Discuss vapour compression system components and calculate cop.	CLO 14	T3:27.18 R4:12.19
58-59	Explain vapour absorption system-mechanical details- working principle.	CLO 15	T3:27.18 R4:15.20
59-60	Problems on p-h chart.	CLO 15	T2:27.18 R4:15.19

XVI. 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	Concepts related to thermodynamic laws, Working principles of IC engines, Analysing the compressors, Concepts of power and refrigeration cycles	Seminars / NPTEL	PO 2,PO 3	PSO 1
3	Encourage students to solve real time applications and prepare towards competitive examinations.	NPTEL	PO 2,PO 6	PSO 1

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