INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad -500 043

AIRCRAFT PROPULSION

COURSE DESCRIPTOR

Course Title	**AIRCRAFT PROPULSION**				
Course Code	AAE007				
Programme	B.Tech				
Semester	V	AE			
Course Type	Core				
Regulation	IARE - R16				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	-	3	-	-
Chief Coordinator	Dr. Prashant GK, Associate Professor				
Course Faculty	Dr. Maruthupandiyan, Associate Professor Dr. Prashant GK, Associate Professor				

I. COURSE OVERVIEW:

This course presents Aircraft propulsive devices as systems, with functional requirements and engineering and environmental limitations along with requirements and limitations that constrain design choices. Both air-breathing and rocket engines are covered, at a level which enables rational integration of the propulsive system into an overall vehicle design. Mission analysis, fundamental performance relations, and exemplary design solutions are presented.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AME003	IV	Thermodynamics	4
UG	AAE003	III	Fluid Mechanics and Hydraulics	4

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Aircraft Propulsion	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Chalk & Talk	✓	Quiz	✓	Assignment	✗	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	25	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
PO1	**General knowledge:** An ability to apply the knowledge of mathematics, science and Engineering for solving multifaceted issues of Aeronautical Engineering	3	Assignments, Term paper
PO2	**Problem Analysis:** An ability to communicate effectively and to prepare formal technical plans leading to solutions and detailed reports for Aeronautical systems	2	Quiz
PO3	**Design/Development of solutions:** To develop Broad theoretical knowledge in Aeronautical Engineering and learn the methods of applying them to identify, formulate and solve practical problems involving Aerodynamics	2	Seminar, Videos,
PO4	**Conduct investigations of complex problems:** An ability to apply the techniques of using appropriate technologies to investigate, analyze, design, simulate and/or fabricate/commission complete systems involving complex aerodynamics flow situations	3	Assignments
PO11	**Project management and finance:** To be familiar with project management problems and basic financial principles for a multi-disciplinary work.	1	Assignments, Seminars

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSOs)		Strength	Proficiency assessed by
PSO1	**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	Lecture, 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	3	Assignments
PSO3	**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	1	Seminar /Industrial visits
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	Analyze parametric cyclic analysis, performance parameters, efficiency, and specific impulse of all air breathing engines.
II	Know the design and performance of subsonic and supersonic inlets, types of combustion chambers and factors affecting the combustors
III	Discuss the types of nozzles, flow conditions in nozzles, interaction of nozzle flow with adjacent surfaces and thrust reversal
IV	Explain different types of compressors and turbines, work done, velocity diagrams and stage efficiency calculations.

IX. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO1	Describe the various types, basic function, and performance analysis of air-breathing engine.	CLO 1	Apply knowledge and understand the essential facts, concepts and principles of thermodynamics.
		CLO 2	Understand the basic function of all aircraft engine components and how they work.
		CLO 3	Analyze the engine performance parameters and parameters influencing them.
		CLO 4	Understand the impact of performance parameters on endurance and range how they affect the aircraft performance.
		CLO 5	Demonstrate different type's aircraft engine operating principle.
		CLO 6	Understand step by step procedure of engine parametric cycle analysis.
		CLO 7	Understand steps involved in performance analysis of all aircraft engine.
CO2	Understand the various inlets and combustion chamber performance parameters affecting it.	CLO 8	Describe operational modes of subsonic inlets and parameters influencing it.
		CLO 9	Analyze diffuser performance, losses in it and their impact on engine performance.
		CLO 10	Describe supersonic inlets, starting problem in it and their operating modes.
		CLO 11	Understand different types of combustion chamber and functions of all the components.
		CLO 12	Analyze combustion chamber performance and parameters influencing them.
CO3	Explain theory of flow in isentropic nozzles and variable area nozzle	CLO 13	Describe theory of flow in isentropic nozzle and physics behind nozzle operation.
		CLO 14	Understand different nozzle operating conditions for convergent and divergent nozzle.
CO4	Describe principle operations of compressors, with work done and pressure rise explaining the design and performance parameters	CLO 15	Describe principle of operation of axial and centrifugal compressor.
		CLO 16	Understand different design of compressor and limitations of each method.
		CLO 17	Analyze performance characteristics of axial and centrifugal compressor.

CO5	Determine the various types of turbine, understand configuration associated with it	CLO 18	Describe principle of operation of centrifugal and axial flow turbine.
		CLO 19	Understand different design of axial and centrifugal turbine.
		CLO 20	Design of ramjet engine and steps involved in it.

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
AAE007.01	CLO 1	Apply knowledge and understand the essential facts, concepts and principles of thermodynamics.	PO 1	3
AAE007.02	CLO 2	Understand the basic function of all aircraft engine components and how they work.	PO 3	2
AAE007.03	CLO 3	Analyze the engine performance parameters and parameters influencing them.	PO 4	3
AAE007.04	CLO 4	Understand the impact of performance parameters on endurance and range how they affect the aircraft performance.	PO 1	3
AAE007.05	CLO 5	Demonstrate different type's aircraft engine operating principle.	PO 1	3
AAE007.06	CLO 6	Understand step by step procedure of engine parametric cycle analysis.	PO 11	1
AAE007.07	CLO 7	Understand steps involved in performance analysis of all aircraft engine.	PO 3	2
AAE007.08	CLO 8	Describe operational modes of subsonic inlets and parameters influencing it.	PO 4	3
AAE007.09	CLO 9	Analyze diffuser performance, losses in it and their impact on engine performance.	PO 2	2
AAE007.10	CLO 10	Describe supersonic inlets, starting problem in it and their operating modes.	PO 1	3
AAE007.11	CLO 11	Understand different types of combustion chamber and functions of all the components.	PO 1	3
AAE007.12	CLO 12	Analyze combustion chamber performance and parameters influencing them.	PO 11	1
AAE007.13	CLO 13	Describe theory of flow in isentropic nozzle and physics behind nozzle operation.	PO 1	3
AAE007.14	CLO 14	Understand different nozzle operating conditions for convergent and divergent nozzle.	PO 11	1
AAE007.15	CLO 15	Describe principle of operation of axial and centrifugal compressor.	PO 1	3
AAE007.16	CLO 16	Understand different design of compressor and limitations of each method.	PO 3	2
AAE007.17	CLO 17	Analyze performance characteristics of axial and centrifugal compressor.	PO 2	2
AAE007.18	CLO 18	Describe principle of operation of centrifugal and axial flow turbine.	PO 1	3
AAE007.19	CLO 19	Understand different design of axial and centrifugal turbine.	PO 4	3
AAE007.20	CLO 20	Design of ramjet engine and steps involved in it.	PO 11	1

3 = High; 2 = Medium; 1 = Low

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

Course Outcomes (COs)	Program Outcomes					Program Specific Outcomes		
	PO1	PO2	PO3	PO4	PO11	PSO1	PSO2	PSO3
CO1	3		2	3	1	2	3	
CO2	3	2		3	1	2		1
CO3	3				1	2		
CO4	3	2	2		1		3	1
CO5	3			3	1		3	1

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XII. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC 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													3		
CLO 2			2										2		1	
CLO 3				3										3		
CLO 4	3															
CLO 5	3												2		1	
CLO 6											1				1	
CLO 7			2											3		
CLO 8				3										3		
CLO 9		2											2		1	
CLO 10	3															
CLO 11	3													3	1	
CLO 12											1		2			
CLO 13	3														1	
CLO 14											1			3		
CLO 15	3												2		1	
CLO 16			2												1	
CLO 17		2												3		
CLO 18	3												2			
CLO 19				3										3		
CLO 20											1		2		1	

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XIII. ASSESSMENT METHODOLOGIES – DIRECT

CIE Exams	PO1, PO2, PO3, PO4, PO11	SEE Exams	PO1, PO2, PO3, PO4, PO11	Assignments	PO1, PO4, PO11	Seminars	PO3, PO11
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	PO1						

XIV. ASSESSMENT METHODOLOGIES – INDIRECT

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

XV. SYLLABUS

MODULE-I	**AIR-BREATHING ENGINES**
Classification, operational envelopes; Description and function of gas generator, turbojet, turbofan, turboprop, turbo-shaft, ramjet, scramjet, turbojet/ramjet combined cycle engine; Engine thrust, takeoff thrust, installed thrust, thrust equation; Engine performance parameters, specific thrust, specific fuel consumption and specific impulse, thermal efficiency, propulsive efficiency, engine overall efficiency and its impact on aircraft range and endurance; Engine cycle analysis and performance analysis for turbojet, turbojet with afterburner, turbofan engine, turboprop engine.	
MODULE-II	**INLETS AND COMBUSTION CHAMBERS**
Internal flow and stall in subsonic inlets, relation between minimum area ratio and eternal deceleration ratio, diffuser performance, supersonic inlets, starting problem on supersonic inlets, shock swallowing by area variation; Classification of combustion chambers, combustion chamber performance, effect of operating variables on performance, flame stabilization.	
MODULE-III	**NOZZLES**
Theory of flow in isentropic nozzles, nozzles and choking, nozzle throat conditions, nozzle efficiency, losses in nozzles. Over expanded and under expanded nozzles, ejector and variable area nozzles, interaction of nozzle flow with adjacent surfaces, thrust reversal	
MODULE-IV	**COMPRESSORS**
Principle of operation of centrifugal compressor and axial flow compressor, work done and pressure rise, velocity triangles, degree of reaction, free vortex and constant reaction designs of axial flow compressor, performance characteristics of centrifugal and axial flow compressors, stage efficiency calculations, cascade testing	
MODULE-V	**TURBINES**
Principle of operation of axial flow turbines, limitations of radial flow turbines, work done and pressure rise, velocity triangles, degree of reaction, free vortex and constant angle designs, performance characteristics, sample ramjet design calculations, flame stability problems in ramjet combustors, integral ram rockets	

Text Books:
1. Hill, P.G. & Peterson, C.R. ―Mechanics & Thermodynamics of Propulsion‖ Addison Wesley Longman INC, 1999. 2. Mattingly J.D., ―Elements of Propulsion: Gas Turbines and Rocket, AIAA, 1991.
Reference Books:
1. Cohen, H.Rogers, G.F.C. and Saravanamuttoo, H.I.H. ―Gas Turbine Theory, Longman, 1989. 2. Oates, G.C., ―Aero thermodynamics of Aircraft Engine Components, AIAA Education Series, New York, 1985.

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 function of gas generator. Classify gas turbine engines	CO1	T2-1.1 , 1.31.4 and 1.7
3-4	Define engine thrust, takeoff thrust. Explain thrust equation	CO1	T1- 1.2,1.8,1.9
5-7	Explain performance parameters	CO1	T2- 1.15, 1.16
8-10	Discuss engine cycle analysis Calculate problems on performance analysis	CO1	T2- 1.6
11-12	Define stall in inlets. Explain relation between minimum area ratio and external acceleration	CO2	T2- 2.2, 2.6
13-14	Explain starting problem on supersonic inlets Discuss shock swallowing by area variation	CO2	R1-2.6, 2.10
15-17	Classify combustion chamber. Explain combustion chamber performance	CO2	T2-3.2, 3.3,
18-20	Discuss effect of operating variables on performance. Define flame stabilization	CO2	T2-3.5
21-23	Explain theory of flow in nozzle. Define nozzle chocking	CO3	T2-2.13, 2.14and 2.16
24-25	Discuss nozzle throat conditions. Calculate problems in nozzle efficiency	CO3	R2-2.15
26-27	Explain over-expanded and under expanded nozzle. Discuss variable area nozzle	CO3	R2-3.9, 3.6
28	Explain thrust reversal	CO3	T2-6.1, 6.3
29	Explain principle of operation of compressor	CO4	T1-6.2, 6.3
30-31	Discuss work done and pressure rise. Design velocity triangle. Define degree of reaction	CO4	T2-6.5, 6.6
32-33	Discuss free vortex and constant reaction design Solve design problems	CO4	R1-6.7, 6.8
34-35	Discuss performance characteristics of centrifugal compressor	CO4	T2-7.1
36	Calculate stage efficiency	CO4	T1- 7.2, 7.3 and 7.4
37-38	Explain principle of operation of turbine. Discuss limitation of radial flow turbines	CO5	T2- 7.9

39-40	Discuss work done and pressure rise. Design velocity triangle. Define degree of reaction	CO5	T2-7.9, 7.10
41-42	Discuss free vortex and constant reaction design Solve design problems	CO5	T2- 7.11
43	Solve problems in ramjet design	CO5	T2- 10.1, 10.2, 10.3
44-45	Explain flame stability in ramjet combustors. Discuss integral ram rockets	CO5	T2-10.4, 10.5

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

S No	Description	Proposed Actions	Relevance With POs	Relevance With PSOs
1	Design of gas turbine for industrial application	Guest lecture/Industrial visit	PO1,PO2,PO4, PO5	PSO2
2	Design and development of compressor for steam turbine application	Seminar/ Guest Lecture	PO6,PO5	PSO2,PSO4
3	Design and development of micro gas turbine	Seminar/ Guest Lecture	PO6,PO5	PSO2,PSO3

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