INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad -500 043

AERONAUTICAL ENGINEERING

COURSE DESCRIPTOR

Course Title	**ROCKET AND MISSILES**				
Course Code	AAE518				
Programme	B.Tech				
Semester	VIII	AE			
Course Type	Elective				
Regulation	IARE - R16				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	-	3	-	-
Chief Coordinator	Mr. V. Phaninder Reddy, Assistant Professor				
Course Faculty	Mr. V. Phaninder Reddy, Assistant Professor				

I. COURSE OVERVIEW:

This course Rockets and Missiles aims to develop a deep knowledge in the direction of space technology. This course utilizes the basic knowledge and understanding that a student has gained from basic engineering courses toward the practical space application.

II. COURSEPRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AAE007	V	Aircraft Propulsion	3
UG	AAE012	VI	Space Propulsion	4
UG	AAE016	VII	Space Mechanics	4

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Rocket And Missiles	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V. EVALUATIONMETHODOLOGY:

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 aquestion.

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 CIEexams.

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	Presentations on real world problems
PO 2	**Problem analysis**: An ability to identify, formulate and solve problems in key areas of Aerodynamics, Structures, Propulsion, Flight Dynamics and Control, Design, Testing, Space and Missile Technologies and Aviation of Aeronautical Engineering discipline.	3	Assessing real-world problems by case study
PO 3	**Design/development of solutions**: An ability to design and conduct experiments, analyze and interpret data related to various areas of Aeronautical Engineering.	2	Seminar/ Research papers

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES AREASSESSED:

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	Lectures, Assignments, 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.	3	Tutorials, Software Practice
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	1	Assignment
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.	-	Seminars

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES:

The course should enable the students to:	
I	Learn Fundamentals of rocket and missile systems, functions and disciplines and the full spectrum of rocket systems, uses and technologies
II	Understand the Fundamentals and uses of solid, liquid and hybrid rocket systems and differences between systems built as weapons and those built for commerce.
III	Explain the use of low and high fidelity performance modeling, including performance loss factors, Staging theory, performance and practices for multi-stage rockets.
IV	Discuss the reliability issues in rocket systems, and strategies to improve reliability, including random and systematic failures, non-linier reliability curves.

IX. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Describe the Classification of launch vehicles and missiles	CLO 1	List out the classification of launch vehicles and missiles, rocket systems, airframe component

COs	Course Outcome	CLOs	Course Learning Outcome
	and its dynamics	CLO 2	Acquire the basic knowledge on forces and moments acting on a rocket, propulsion, aerodynamics, gravity of rocket missiles
		CLO 3	Examine the equations of motion for three-dimensional motion through atmosphere and vacuum, earth's atmosphere, numerical problems
CO 2	Differentiating the components of and the design considerations of solid and hybrid rocket systems and some design problems	CLO 4	Illustrate the solid propellant rockets and enlist components and their design considerations, propellant grain design
		CLO 5	Demonstrate the ballistics and burn rate design issues, igniter design, types of nozzles, thrust vector control, pyrotechnic devices and systems
		CLO 6	List out the classification, mechanisms and application of pyrotechnic devices in rockets and missiles; design problems in rocket systems.
CO 3	Understanding the concept of liquid propulsion system ,component classification and design problems in rocket systems	CLO 7	Describing the Liquid propellant rockets, classification and components.
		CLO 8	Understanding the concepts of thrust chamber, feed systems, propellant tanks, turbo-pumps, types of valves and applications, design considerations.
		CLO 9	Differentiate the bipropellant systems like cryogenics and their characteristics
CO 4	Estimation of optimization techniques od navigation and guidance system in rockets ,missiles and its aerodynamics control systems	CLO 10	Interpret Navigation and guidance systems in rockets and missiles, aerodynamic control systems of missiles
		CLO 11	Categorize multi-staging of rockets, vehicle optimization techniques, stage separation system
		CLO 12	Identify the separation techniques which are used for rocket flight dispersion, numerical problems
CO 5	Acquiring knowledge on design, materials and testing of rockets space environment on the selection of materials for rockets and spacecraft	CLO 13	Design requirements and selection, performance evaluation and assessment, space environment on the selection of materials for rockets and spacecraft
		CLO 14	Describe the material selection for specific requirements, advance materials, super alloys and composite materials
		CLO 15	Examine the qualification of rocket and missile systems, types of testing and evaluation of design and function.

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
AAE518.01	CLO 1	List out the classification of launch vehicles and missiles, rocket systems, airframe component	PO 1	3
AAE518.02	CLO 2	Acquire the basic knowledge on forces and moments acting on a rocket, propulsion, aerodynamics, gravity of rocket missiles	PO 1	2
AAE518.03	CLO 3	Examine the equations of motion for three-dimensional motion through atmosphere and vacuum, earth's atmosphere, numerical problems	PO 1	3
AAE518.04	CLO 4	Illustrate the solid propellant rockets and enlist components and their design considerations, propellant grain design	PO 1 PO 2	1
AAE518.05	CLO 5	Demonstrate the ballistics and burn rate design issues, igniter design, types of nozzles, thrust vector control, pyrotechnic devices and systems	PO 1, PO 2	2

AAE518.06	CLO 6	List out the classification, mechanisms and application of pyrotechnic devices in rockets and missiles; design problems in rocket systems.	PO 1	3
AAE518.07	CLO 7	Describing the Liquid propellant rockets, classification and components.	PO 1 PO 2	1
AAE518.08	CLO 8	Understanding the concepts of thrust chamber, feed systems, propellant tanks, turbo-pumps, types of valves and applications, design considerations.	PO 1 PO 2	2
AAE518.09	CLO 9	Differentiate the bipropellant systems like cryogenics and their characteristics	PO 1	2
AAE518.10	CLO 10	Interpret Navigation and guidance systems in rockets and missiles, aerodynamic control systems of missiles	PO 1	2
AAE518.11	CLO 11	Categorize multi-staging of rockets, vehicle optimization techniques, stage separation system	PO 1	1
AAE518.12	CLO 12	Identify the separation techniques which are used for rocket flight dispersion, numerical problems	PO 1 PO 2	3
AAE518.13	CLO 13	Design requirements and selection, performance evaluation and assessment, space environment on the selection of materials for rockets and spacecraft	PO 3	2
AAE518.14	CLO 14	Describe the material selection for specific requirements, advance materials, super alloys and composite materials	PO 2	1
AAE518.15	CLO 15	Examine the qualification of rocket and missile systems, types of testing and evaluation of design and function.	PO 1 PO 4	2

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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 4
CO 1	2	1		
CO 2	2	1		
CO 3	2	1		
CO 4	1	1	1	1
CO 5	3	1		1

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

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

3 = High; 2 = Medium; 1 = Low

XIII.ASSESSMENTMETHODOLOGIES–DIRECT

CIE Exams	PO 1, PO 2 PO 3, PO 4 PSO1, PSO2	SEE Exams	PO 1, PO 2 PO 3, PO 4 PSO1, PSO2	Assignments	PO 4	Seminars	PO 2
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	PO 1 PO 2						

XIV.ASSESSMENTMETHODOLOGIES-INDIRECT

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

XV. SYLLABUS

UNIT-I	ROCKET DYNAMICS
Classification of launch vehicles and missiles, rocket systems, airframe components, forces and moments acting on a rocket, propulsion, aerodynamics, gravity, inertial and non-inertial frames, coordinate transformation, equations of motion for three-dimensional motion through atmosphere and vacuum, earth's atmosphere, numerical problems.	
UNIT-II	**SOLID PROPULSION AND PYROTECHNICS**
Solid propellant rockets, classification, components and their design considerations, propellant grain design, grain mechanical properties, ballistics and burn rate design issues, igniter design, types of nozzles, thrust vector control, pyrotechnic devices and systems, classification, mechanisms and application of pyrotechnic devices in rockets and missiles; design problems in rocket systems.	
UNIT-III	**LIQUID PROPULSION AND CONTROL SYSTEMS**
Liquid propellant rockets, classification and components, thrust chamber, feed systems, propellant tanks, turbo-pumps, types of valves and applications, design considerations. Different bipropellant systems like cryogenics and their characteristics, pogo and slooh engine gimbal systems and thrusters for control; Spacecraft propulsion and control systems design problems.	
UNIT-IV	**MULTI-STAGING OF ROCKET AND SEPERATION DYNAMICS**
Navigation and guidance systems in rockets and missiles, aerodynamic control systems of missiles, multistaging of rockets, vehicle optimization techniques, stage separation system, dynamics, separation techniques, rocket flight dispersion, numerical problems.	
UNIT-V	**DESIGN, MATERIALS AND TESTING OF ROCKETS**
Design requirements and selection, performance evaluation and assessment, space environment on the selection of materials for rockets and spacecraft, material selection for specific requirements, advance materials, super alloys and composite materials, qualification of rocket and missile systems, types of testing and evaluation of design and function	
Text Books:	
1. Sutton, G.P., et al., "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 1993. 2. Martin J.L Turner , "Rocket & Space Craft Propulsion", Springers –oraxis publishing, 2001.	
Reference Books:	
1. Mathur, M., and Sharma, R.P., "Gas Turbines and Jet and Rocket Propulsion", Standard Publishers, New Delhi 1998 2. Cornelisse, J.W., "Rocket Propulsion and Space Dynamics", J.W., Freeman & Co. Ltd., London, 1982. 3. Parker, E.R., "Materials for Missiles and Spacecraft", McGraw-Hill Book Co. Inc., 1982.	

XVI. COURSEPLAN:

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	Classification of launch vehicles and missiles	CLO 1	T2: 1.1-1.5, T1: 4.1
3-4	Rocket systems, airframe components, forces and moments acting on a rocket, propulsion	CLO 1	T2: 2.1-2.2, R1: 3.1
5-6	Aerodynamics, gravity, inertial and non-inertial frames	CLO 2	T2: 2.3-2.4
7-8	Components, forces and moments acting on a rocket, propulsion, aerodynamics, gravity	CLO 2	T2: 2.5-2.6,
9-10	Inertial and non-inertial frames, coordinate transformation, equations of motion for three-dimensional motion through atmosphere	CLO 3	T2: 3.3
11	Vacuum, earth's atmosphere, numerical problems	CLO 4	T2: 3.4, R1:4.1
12	Solid propellant rockets, classification, components,	CLO 5	T2: 3.4
13-14	Their design considerations, propellant grain design,	CLO 5	T2: 3.3

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
	grain mechanical properties.		
15-16	Ballistics and burn rate design issues, igniter design,	CLO 6	T2: 4.2
17-18	Types of nozzles, thrust vector control	CLO 6	T2: 5.1
19-20	Pyrotechnic devices and systems, classification;	CLO 7	T2: 5.2
21-22	Mechanisms and application of pyrotechnic devices in rockets and missilesdesign problems in rocket systems.	CLO 7	T2: 5.3
23-24	Liquid propellant rockets, classification and components	CLO 8	T2: 4.5
25-26	Thrust chamber, feed systems, propellant tanks, turbo-pumps, types of valves and applications, design considerations.	CLO 8	T1: 4.1
27-28	Different bipropellant systems like cryogenics and their characteristics, pogo and slooh engine gimbal systems and thrusters for control	CLO 9	T1: 4.2
29-30	Spacecraft propulsion and control systems design problems	CLO 9	T1: 4.3
31-38	Navigation and guidance systems in rockets and missiles	CLO 10	T2: 5.2
39-40	Aerodynamic control systems of missiles, multistage of rockets	CLO 10	T2: 5.2
41-42	Vehicle optimization techniques, stage separation system	CLO 11	T2: 5.2
43-44	Dynamics, separation techniques	CLO 13	T1: 7.1
45-46	Rocket flight dispersion, numerical problems.	CLO 14	T1: 7.2
47-49	Design requirements and selection, performance evaluation and assessment	CLO 14	T1: 7.4
50	Space environment on the selection of materials for rockets	CLO 15	T1: 7.5, R2: 7.3
51	Space environment on the selection of materials for spacecraft	CLO 15	T1: 7.5
52	Material selection for specific requirements, advance materials,	CLO 15	T1: 7.6
53	Super alloys and composite materials	CLO 15	T1: 7.5, R2: 7.4
54	Qualification of rocket and missile systems	CLO 15	T1: 7.7
55	Types of testing and evaluation of design and function	CLO 15	R2:7.5

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

S No	Description	Proposed actions	Relevancewith POs	Relevance with PSOs
1	To improve standards and analyze the concepts.	Seminars	PO 1	PSO 1
2	To understand definitions better and be able to derive critical equations.	Seminars /	PO 3, PO 2	PSO 1
3	Develop trajectories and equations of motion for the various aspects of space flight	Seminars/ internship	PO 2	PSO 1

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