INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad -500 043

AERONAUTICAL ENGINEERING

COURSE DESCRIPTOR

Course Title	**MECHANISM AND MACHINE DESIGN**				
Course Code	AAE523				
Programme	B. Tech				
Semester	V	AE			
Course Type	Professional Elective				
Regulation	IARE - R16				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	-	3	-	-
Chief Coordinator	Mr. M Vijay Kumar, Assistant Professor				
Course Faculty	Mr. M Vijay Kumar, Assistant Professor				

I. COURSE OVERVIEW:

Mechanical devices are designed to have mobility to perform certain functions. The theory behind the study of Kinematics of Machine leads us to design machines by understanding the relationship between the geometry and the motion of various parts of machine. This course will provide the knowledge on how to analyze the motions of mechanisms and design synthesis mechanisms to give required mobility. This includes relative motion analysis and design of gears, gear trains, cams, linkages and steering mechanism gears by adopting simultaneously both graphical and analytical approaches to estimate displacement, velocity and acceleration of links in a machine.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AME001	I	Engineering Drawing	4
UG	AME002	II	Engineering Mechanics	4

III. MARKSDISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Mechanism and Machine Design	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	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.

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		Strength	Proficiency assessed by
PO1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Presentation on real-world problems
PO2	**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.	2	Seminar
PO3	**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.	1	Assignment

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
PSO 2	**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 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 basic principles of kinematics and the related terminology of machines
II	Discriminate mobility; enumerate links and joints in the mechanisms.
III	Formulate the concept of analysis of different mechanisms
IV	Develop the working of various straight line mechanisms, gears, gear trains, steering gear mechanisms, cams and a Hooke's joint
V	Analyze a mechanism for displacement, velocity and acceleration of links in machine

IX. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Describe the concept of mechanisms and machines in which all the links and their mechanism studied.	CLO 1	Understand the kinematic links, kinematic pairs and formation of the kinematic chain.
		CLO 2	Distinguish between mechanism and machine.
		CLO 3	Design and develop inversions of quadratic cycle chain, slider crank mechanism, and double slider crank mechanism and cross slider mechanism.
		CLO 4	Demonstrate type synthesis, number synthesis and dimensional synthesis.
CO 2	Determine the velocity and acceleration diagrams for different mechanisms using graphical methods.	CLO 5	Construct Graphical methods of velocity polygon and acceleration polygons for a given configuration diagram.
		CLO 6	Understand other methods of acceleration diagrams like Klien's construction.
		CLO 7	Develop secondary acceleration component i.e. Correli's component involving quick return mechanisms
		CLO 8	Alternative approach for determining velocity by using I centers and centroids methods.
CO 3	Understand the concept of plane motion of body and gyroscopic motion precession in which gyroscopic mechanism is studied.	CLO 09	Significance of relative motion between two bodies, three centre's in line theorem
		CLO 10	Application of instantaneous centre, simple mechanisms and determination of angular velocity of points and links
		CLO 11	Applications of gyroscope, free and restrained, working principle, the free gyro, rate gyro, integrating gyro as motion measuring instruments
		CLO 12	The effect of precession on the stability of vehicles, Applications of motorbikes, automobiles, airplanes and ships
CO 4	Explore the concept of cams and followers, steering gear mechanism to understand real time applications of mechanisms.	CLO 13	Develop the Cam profiles and followers design
		CLO 14	Understand the uniform velocity, simple harmonic motion and uniform acceleration, maximum velocity and acceleration during outward and return strokes
		CLO 15	Understand the Davis steering gear, Ackerman's steering gear, velocity ratio
		CLO 16	Understand the hook's joint, single and double hooks joint, universal coupling, applications.
CO 5	Introduction to gears and gear mechanism where different tooth profiles of gear is designed.	CLO 17	Derive the expression for minimum number of teeth to avoid interference in case of pinion and gear as well as rack and pinion.
		CLO 18	Application of different gear trains including epi-cyclic and deduce the train value using tabular and relative velocity method.
		CLO 19	Significance of differential gear box in an automobile while taking turn on the road.
		CLO 20	Enable the students to understand the importance of Freudenstein equation, Precession point synthesis, Chebyshev's method, structural error

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
AAE523.01	CLO 1	Understand the kinematic links, kinematic pairs and formation of the kinematic chain.	PO 1	3
AAE523.02	CLO 2	Distinguish between mechanism and machine.	PO 1	3
AAE523.03	CLO 3	Design and develop inversions of quadratic cycle chain, slider crank mechanism, and double slider crank mechanism and cross slider mechanism.	PO 1	3
AAE523.04	CLO 4	Demonstrate type synthesis, number synthesis and dimensional synthesis.	PO 2	2
AAE523.05	CLO 5	Construct Graphical methods of velocity polygon and acceleration polygons for a given configuration diagram.	PO 1, PO 2	3
AAE523.06	CLO 6	Understand other methods of acceleration diagrams like Klien's construction.	PO 1, PO 2	2
AAE523.07	CLO 7	Develop secondary acceleration component i.e Correli's component involving quick return mechanisms	PO 2	1
AAE523.08	CLO 8	Alternative approach for determining velocity by using I centers and centroids methods.	PO 2	1
AAE523.09	CLO 9	Significance of relative motion between two bodies, three centre's in line theorem	PO 2	2
AAE523.10	CLO 10	Application of instantaneous centre, simple mechanisms and determination of angular velocity of points and links	PO 2	2
AAE523.11	CLO 11	Applications of gyroscope, free and restrained, working principle, the free gyro, rate gyro, integrating gyro as motion measuring instruments	PO 1	3
AAE523.12	CLO 12	The effect of precession on the stability of vehicles, Applications of motorbikes, automobiles, airplanes and ships	PO 1, PO 3	3
AAE523.13	CLO 13	Develop the Cam profiles and followers design	PO 1	3
AAE523.14	CLO 14	Understand the uniform velocity, simple harmonic motion and uniform acceleration, maximum velocity and acceleration.	PO 1, PO 2	3
AAE523.15	CLO 15	Understand the Davis steering gear, Ackerman's steering gear, velocity ratio	PO 3	2
AAE523.16	CLO 16	Understand the hook's joint, single and double hooks joint, universal coupling, applications.	PO 1, PO 2	2
AAE523.17	CLO 17	Derive the expression for minimum number of teeth to avoid interference in case of pinion and gear as well as rack and pinion.	PO 2	3
AAE523.18	CLO 18	Application of different gear trains including epi-cyclic and deduce the train value using tabular and relative velocity method.	PO 2	2
AAE523.19	CLO 19	Significance of differential gear box in an automobile while taking turn on the road.	PO 3	3
AAE523.20	CLO 20	Enable the students to understand the importance of Freudenstein equation, Precession point synthesis, Chebyshev's method, structural error	PO 3	3

3 = High; 2 = Medium; 1 = Low

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

Course Outcomes (COs)	Program Outcomes (POs)			
	PO 1	PO 2	PO 3	PSO 1
CO 1	3	2		2
CO 2	3	2		2
CO 3	3	2	1	
CO 4	3	2	1	
CO 5		2	1	2

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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	PSO4
CLO 1	3												2			
CLO 2	3															
CLO 3	3															
CLO 4		2														
CLO 5	3	3											2			
CLO 6	2	2														
CLO 7		1														
CLO 8		1														
CLO 9		2														
CLO 10		2														
CLO 11	3															
CLO 12	3		3													
CLO 13	3															
CLO 14	3	3														
CLO 15			2													
CLO 16	2	2														
CLO 17		3														
CLO 18		2														
CLO 19			3													

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 20			3										2			

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XIII. ASSESSMENT METHODOLOGIES–DIRECT

CIE Exams	PO 1, PO2, PO3, PSO1	SEE Exams	PO 1, PO2, PO3, PSO1	Assignments	PO3	Seminars	PO 1, PO2, PO3, PSO1
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	PO 1, PO2, PO3, PSO1						

XIV. ASSESSMENT METHODOLOGIES-INDIRECT

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

XV. SYLLABUS

UNIT-I	MECHANISMS & MACHINES
Elements of links, classification, rigid link, flexible and fluid link, types of kinematic pairs, sliding, turning, rolling, screw and spherical pairs, lower and higher pairs, closed and open pairs, constrained motion, completely, partially or successfully constrained, and incompletely constrained, mechanism and machines, classification, kinematic chain, inversion of mechanism, inversion of quadratic cycle, chain, single and double slider crank chains; Exact and approximate straight line mechanisms: Paucellier, hart t, Chibichef, pantograph.	
UNIT-II	**KINEMATIC ANALYSIS OF MECHANISMS**
Velocity and acceleration, motion of link in machine, determination of velocity and acceleration diagrams, graphical method, application of relative velocity method for four bar chain, analysis of slider crank chain for displacement, velocity and acceleration of sliding, acceleration diagram for a given mechanism, Kleins construction, Coriolis acceleration, determination of Coriolis component of acceleration.	
UNIT-III	**PLANE MOTION OF BODY & GYROSCOPIC MOTION PRECESSION**
Instantaneous centre of rotation, centroids and axodes, relative motion between two bodies, three centre's in line theorem, graphical determination of instantaneous centre, diagrams for simple mechanisms and determination of angular velocity of points and links. The gyroscope, free and restrained, working principle, the free gyro, rate gyro, integrating gyro as motion measuring instruments, effect of precession on the stability of vehicles, motorbikes, automobiles, airplanes and ships, static and dynamic forces generated due to in precession in rotating mechanisms.	
UNIT-IV	**CAMS AND FOLLOWERS, STEERING GEARS**
Cams and followers, definition uses, types, terminology, types of follower motion, uniform velocity, simple harmonic motion and uniform acceleration, maximum velocity and acceleration during outward and return strokes, roller follower, circular cam with straight, concave and convex flanks, condition for correct steering, Davis steering gear, Ackerman's steering gear, velocity ratio, hook's joint, single and double hooks joint, universal coupling, applications.	

UNIT-V	GEARS AND GEAR TRAINS, DESIGN OF FOUR BAR MECHANISMS
Introduction to gears: Types, law of gearing; Tooth profiles: Specifications, classification, helical, bevel and worm gears, simple and reverted gear train, epicyclic gear trains, velocity ratio or train value, four bar mechanism, Freudenstein equation, Precession point synthesis, Chebyshev's method, structural error.	
TEXT BOOKS:	
1. Amithab Ghosh, Asok Kumar Malik, ―Theory of Mechanisms and machines, East West Press Pvt Ltd, 2001. 2. J. S. Rao, R.V. Dukkipati ―Mechanism and Machine Theory / New Age Publications‖, 1996.	
REFERENCES:	
1. Jagadish Lal, "Theory of Mechanisms and Machines", Metropolitan Book Company, 1st Edition, 1978. 2. P. L. Ballaney, ―Theory of Machines‖, Khanna Publishers, 3rd Edition, 2003.	

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	Elements of links, classification, rigid link, flexible and fluid link	CLO1	T1:1.2, R1:5.2
2	Types of kinematic pairs, sliding, turning, rolling, screw and spherical pairs	CLO1	T1:1.3
3	Lower and higher pairs, closed and open pairs	CLO1	T1:1.4
4	Constrained motion, completely, Partially or successfully constrained	CLO2	T1:1.6, R1:5.6
5-6	Incompletely constrained, mechanism and machines, Classification, kinematic chain, inversion of mechanism	CLO2	T1:2.2
7-9	Inversion of quadratic cycle ,Single slider crank chains, Double slider crank chains	CLO3	T1:2.4, R1:6.2
10-12	Exact and approximate straight line mechanisms: Paucellier,	CLO4	T1:2.25, R2:4.2
13	Exact and approximate straight line mechanisms: pantograph.	CLO5	T1:2.6
14-15	Velocity and acceleration, motion of link in machine	CLO5	T1:2.8
16	Determination of velocity and acceleration diagrams	CLO6	T1:2.9, R1:6.8
17	Graphical method	CLO6	T1:2.11
18	Application of relative velocity method for four bar chain	CLO6	T1:3.2, R2:4.8
19	Analysis of slider crank chain for displacement,	CLO7	T1:3.4
20	Velocity and acceleration of sliding, acceleration diagram for a given mechanism	CLO7	T1:3.5, R1:5.7
21	Kleins construction	CLO6	T1:3.6
22	Coriolis acceleration	CLO7	T1:3.6
23	Determination of Coriolis component of acceleration.	CLO7	T1:3.8

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
24	Instantaneous centre of rotation, centroids and axodes, relative motion between two bodies,	CLO8	T1:3.9
25	Three centre's in line theorem graphical determination of instantaneous centre,	CLO8	T1:3.9, R2:4.12
26	Diagrams for simple mechanisms and determination of angular velocity of points and links	CLO9	T1:3.12, R2:4.8
27	The gyroscope, free and restrained, working principle,	CLO10	T2:5.1
28	The free gyro, rate gyro, Integrating gyro as motion measuring instruments	CLO10	T2:5.3, R1:5.9
29	Effect of precession on the stability of vehicles,	CLO11	T2:5.4
30	Effect of precession on the stability of motorbikes, automobiles,	CLO12	T2:5.4, R2:4.9
31	Effect of precession on the stability of airplanes and ships,	CLO12	T2:5.7
32	Static and dynamic forces generated due to in precession in rotating mechanisms.	CLO12	T2:5.9, R2:7.2
33	Cams and followers	CLO 13	T1:8.1
34	Definition uses, types, terminology, types of follower motion	CLO 13	T1:8.3, R1:5.2
35	Uniform velocity, simple harmonic motion	CLO 14	T1:8.4, R1:6.3
36	Uniform acceleration	CLO 14	T1:8.8
37	Maximum velocity and acceleration during outward and return strokes,	CLO 14	T1:8.9, R1:7.5
38	Roller follower, circular cam with straight, concave and convex flanks	CLO 14	T1:8.12
39	Condition for correct steering, Davis steering gear, Ackerman's steering gear	CLO 15	T1:7.3, R2:7.6
40	Velocity ratio, hook's joint, single and double hooks, joint Universal coupling, applications	CLO 16	T1:7.8
41	Introduction to gears: Types, law of gearing; Tooth profiles: Specifications, classification	CLO 17	T1:9.1, R1:7.6
42	Helical, bevel, Worm gears	CLO 17	T1:9.2, R2:7.8
43	Simple and reverted gear train	CLO 17	T1:9.3
44	Epicyclic gear trains	CLO 18	T1:9.5, R1:9.5
45	Velocity ratio or train value, four bar mechanism, Freudenstein equation	CLO 19	T1:9.6
46	Precession point synthesis	CLO 20	T1:9.7
47	Chebyshev's method, structural error.	CLO 20	T1:9.9, R2:9.5

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

S No	Description	Proposed actions	Relevance with POs	Relevance with PSOs
1	Broad knowledge of engineering materials and material properties	Seminars / Guest Lectures/ NPTEL	PO 1	PSO 1
2	Practical Exposure about the stress deflections and stability of elements	Seminars / Guest Lectures / NPTEL	PO 3	PSO 1

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