INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTOR

Course Title	**KINEMATICS OF MACHINES**				
Course Code	AME009				
Programme	B.Tech				
Course Type	Core				
Semester	IV	ME			
Regulation	IARE - R16				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	-	-
Chief Coordinator	Dr. K. Viswanath Allamraju, Professor,				
Course Faculty	Dr. K. Viswanath Allamraju, Professor, Prof. V.V.S.H. Prasad, 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	AME002	II	Engineering Mechanics	4
UG	AME001	I	Engineering Drawing	4

III. MARKSDISTRIBUTION

Subject	SEE Examination	CIA Examination	Total Marks
Kinematics of machines	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.

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, with 25 marks for Continuous Internal Examination (CIE) and 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):
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 20 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, micro projects, five minutes video and MOOCs.

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Level	Proficiency assessed by
PO1	Engineering Knowledge: Capability to apply the knowledge of mathematics, science and engineering in the field of mechanical engineering.	3	Presentation on real-world problems
PO2	Problem Analysis: An ability to analyze complex engineering problems to arrive at relevant conclusion using knowledge of mathematics, science and engineering.	3	Seminar
PO3	Design/ development of solutions: Competence to design a system, component or process to meet societal needs within realistic constraints.	3	Seminar
PO4	Conduct investigations of complex problems: To design and conduct research oriented experiments as well as to analyze and implement data using research methodologies.	3	Term Paper

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Level	Proficiency assessed by
PSO1	**Professional Skills:** To produce engineering professional capable of synthesizing and analyzing mechanical systems including allied engineering streams.	3	Lecture, Assignments.
PSO2	**Problem solving skills**: An ability to adopt and integrate current technologies in the design and manufacturing domain to enhance the employability.	3	Projects
PSO3	**Successful career and Entrepreneurship**: To build the nation, by imparting technological inputs and managerial skills to become technocrats.	3	Projects

3= High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES (COs):

The course should enable the students to:	
I	Understand the basic principles of kinematics and the related terminology of machines.
II	Identify mobility; enumerate links and joints in the mechanisms.
III	Explain the concept of analysis of different mechanisms.
IV	Understand the working of various straight line mechanisms, gears, gear trains, steering gear mechanisms, cams and a Hooke's joint.
V	Determine the mechanisms for displacement, velocity and acceleration of links in a machine.

IX. 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
CAME009.01	CLO1	Classifications of the kinematic links, kinematic pairs and formation of the kinematic chain.	PO 1	3

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
CAME009.02	CLO2	Distinguish between mechanism and machine	PO 1, PO 3	3
CAME009.03	CLO3	Design and develop inversions of quadratic cycle chain, slider cranck mechanism, double slider cranck mechanism and cross slider mechanism.	PO 1, PO 3	3
CAME009.04	CLO4	Demonstrate type synthesis, number synthesis and dimensional synthesis.	PO 1, PO 2, PO 4	2
CAME009.05	CLO5	Construct Graphical methods of velocity polygon and acceleration polygons for a given configuration diagram.	PO 1, PO 3	2
CAME009.06	CLO6	Understand other methods of acceleration diagrams like Klien's construction.	PO 1, PO 2, PO 4	2
CAME009.07	CLO7	Develop secondary acceleration component i.e Correli's component involving quick return mechanisms	PO 1, PO 2, PO 3	1
CAME009.08	CLO8	Alternative approach for determining velocity by using I centres and centriods methods.	PO 1, PO 2, PO 3	1
CAME009.09	CLO9	Significance of exact and approximate straight line mechanisms.	PO 1, PO 2	2
CAME009.10	CLO10	Application of straight line mechanism in steam engine indicators.	PO 1, PO 3	2
CAME009.11	CLO11	Applications of Ackerman's and Davi's steering mechanisms in automobiles.	PO 1, PO 3	3
CAME009.12	CLO12	Develop the condition for exact steering.	PO 1, PO 2	3
CAME009.13	CLO13	Develop the polar velocity diagram for a single hook joint and double hook joint and develop condition for unity for higher and lower speeds.	PO 1, PO 3	3
CAME009.14	CLO14	Study different displacement profiles applicable in I.C engines cam shafts.	PO 1, PO 2	2
CAME009.15	CLO15	Plot the displacement, velocity and acceleration profiles with respect to time.	PO 1, PO 3, PO 4	2
CAME009.16	CLO16	Understand the geometry of gears and deduce the expression for arc of contact.	PO 1, PO 2	2
CAME009.17	CLO17	Derive the expression for minimum number of teeth to avoid interference in case of pinion and gear as well as rack and pinion.	PO 1, PO 2	3
CAME009.18	CLO18	Application of different gear trains including epicyclic and deduce the train value using tabular and relative velocity method.	PO 1, PO 2	2
CAME009.19	CLO19	Significance of differential gear box in an automobile while taking turn	PO 1, PO 3, PO 4	1

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
		on the road.		
CAME009.20	CLO20	Enable the students to understand the importance of theory of machines for lifelong learning, Higher Education and competitive exams.	PO 1, PO 2	1

3= High; 2 = Medium; 1 = Low

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

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 20	1	1												2	

XI. ASSESSMENT METHODOLOGIES – DIRECT

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

XII. ASSESSMENT METHODOLOGIES–INDIRECT

√	Assessment of course Outcomes (by feedback, once)	√	Student feedback on faculty (twice)
✘	Assessment of mini projects by experts		

XIII. SYLLABUS:

Unit-I	MECHANISMS
Mechanisms: Elements or links, classification, rigid link, flexible and fluid link, types of kinematic pairs constrained motion, kinematic chain, mechanism, machine, structure, inversion of mechanism, inversions of cycle chain, single and double slider crank chains, mechanical advantage, Grubler's Criterion.	
Unit-II	**KINEMATICS, PLANE MOTION OF BODY, ANALYSIS OF MECHANISMS**
Kinematics: Velocity and acceleration, motion of link in machine, determination of velocity and acceleration, Graphical method, application of relative velocity method, plane motion of body: Instantaneous center of rotation, centroids and axodes, three centers in line theorem, graphical determination of instantaneous center, determination of angular velocity of points and links by instantaneous center method. Klein's construction, Coriolis acceleration, determination of Coriolis component of acceleration; Analysis of mechanisms: Analysis of slider crank chain for displacement, velocity and acceleration of slider, acceleration diagram for a given mechanism.	
Unit-III	**STRAIGHT LINE MOTION MECHANISMS, STEERING GEARS, HOOKE'S JOINT**
Straight-line motion Mechanisms: Exact and approximate copied and generated types, Peaucellier, Hart and Scott Russul, Grasshopper, Watt, TChebicheff and Robert mechanisms, pantograph. Steering gears: Conditions for correct steering, Davis Steering gear, Ackerman's steering gear, Hooke's joint: Single and double Hooke's joint, velocity ratio, application, problems.	
Unit-IV	**CAMS, ANALYSIS OF MOTION OF FOLLOWERS**
Cams: Definitions of cam and followers, their uses, types of followers and cams, terminology, types of follower motion, uniform velocity, simple harmonic motion and uniform acceleration; Maximum velocity and maximum acceleration during outward and return strokes in the above three cases; Analysis of motion of followers: Tangent cam with roller follower, circular arc cam with straight, concave and convex flanks.	
Unit-V	**HIGHER PAIRS, GEAR TRAINS**
Higher Pairs: friction wheels and toothed gears, types, law of gearing, condition for constant velocity ratio for transmission of motion, velocity of sliding, form of teeth, cycloidal and involute profiles, phenomena of interferences, methods of interference; Condition for minimum number of teeth to avoid interference, expressions for arc of contact and path of contact of pinion and gear pinion and rack arrangements; Introduction to helical, bevel and worm gearing; Gear trains: Introduction, types, simple and reverted gear trains, epicyclic gear train; Methods of finding train value or velocity ratio of epicyclic gear trains,	

selection of gear box, differential gear for an automobile.
Text Books:
1. Joseph E. Shigley, "Theory of Machines and Mechanisms", Oxford University Press, 4th Edition, 2010. 2. Thomas Bevan, "Theory of Machines", Pearson, 3rd Edition, 2009.
Reference Books:
1. Jagadish Lal, "Theory of Mechanisms and Machines", Metropolitan Book Company, 8st Edition, 2016. 2. S.S. Rattan, "Theory of Machines", Tata McGraw-Hill Education, 1st Edition, 2009. 3. Norton, "Kinematics and Dynamics of Machinery", Tata McGraw-Hill, 3rd Edition, 2008. 4. Sadhu Singh, "Theory of Machines", Pearson, 2nd Edition, 2006. 5. J. S Rao, R. V Duggipati, "Mechanisms and Machine Theory", New Age Publishers, 2nd Edition, 2008. 6. R. K. Bansal, "Theory of Machines", Lakshmi Publications, 1st Edition, 2013.

XIV. COURSE PLAN:

The course plan is meant as a guideline. There may probably be changes.

Lecture No	Topic/s to be covered	Course Learning Outcomes (CLOs)	Reference
1	Kinematics of Machinery -Introduction Link- Rigid Link, flexible and fluid link Types of kinematic pairs	CLO1	T1-1.1 , R1- 1.31.4 ,R2.1.7
3-4	Types of constrained motion. kinematic chain , Mechanism, Machine and Structure	CLO1	T1- 1.2, R1-1.8,
5-6	inversion of mechanism – inversions of quadric cycle chain, single and double slider crank chains	CLO1	T1- 1.15, R1- 1.16
7-8	Mechanical Advantage and Grubler's Criterion	CLO2	T1- 1.6
9-10	Velocity of link in machine, Vector diagram for velocity.	CLO2	T1- 2.2, R2-2.6
11	Determination of Velocity using Graphical method using relative velocity method.	CLO2	T1-2.6, R3-2.10
12	Acceleration of link in machine, Vector diagram for Acceleration.	CLO3	T1-3.2, R2-3.3,
13-14	Determination of Acceleration using Graphical method	CLO3	T1-3.5
15-16	Instantaneous center of rotation, centroids & axodes and Three centers in line theorem.	CLO4	T1-2.13, 2.14,R1- 2.16
17-18	Graphical determination of instantaneous center, determination of angular velocity of points and links by instantaneous center method	CLO4	T1-2.15, R1-2.15
23-24	Kleins construction, Coriolis acceleration and determination of Coriolis component of acceleration.	CLO4	T1-3.9, R1-3.9
25-27	Exact and approximate copied and generated types straight line mechanisms Peaucellier, Hart, Scott Russul and Grasshopper mechanisms.	CLO5	T1-6.1, R2-6.3

Lecture No	Topic/s to be covered	Course Learning Outcomes (CLOs)	Reference
27-28	Watt, T.Chebicheff and Robert Mechanisms - Pantograph.	CLO6	T1-6.2, R2- 6.3
29-30	Conditions for correct steering – Davis Steering gear, Ackerman's steering gear.	CLO6	T1-6.5, 6.6
33-34	Single and double Hooke's joint – Velocity Ratio – application – problems.	CLO7	T1-6.7, 6.8
37-38	Definitions of cam and followers, their uses	CLO8	T1-7.1
39-40	Types of followers and cams, Terminology, Types of follower motion,	CLO18	T1- 7.2, R1-7.3
41-42	Uniform velocity, Simple harmonic motion	CLO8	T1- 7.9,R1-7.9
43-44	Uniform acceleration. Maximum velocity and maximum acceleration during outward and return strokes in the above 3 cases.	CLO8	T1-7.9, R1-7.10
45-46	Analysis of motion of followers: Tangent cam with Roller follower, circular arc cam with straight concave and convex flanks	CLO9	T1- 7.11,R2-7.12
47-48	Friction wheels and toothed gears and types of gears.	CL010	T1- 10.1, R1-10.2
49-50	Law of gearing -Condition for constant velocity ratio for transmission of motion - Velocity of sliding.	CLO11	T1-10.4,R1- 10.5
51	Form of teeth, cycloidal and involute profiles	CLO12	T1-10.6, 10.7and 10.8
52-53	Phenomena of interferences – Methods of interference. Condition for minimum number of teeth to avoid interference	CLO13	T1- 10.14 and 10.15
54-55	expressions for arc of contact and path of contact of Pinion & Gear	CLO14	T1-10.11
56-57	Pinion and Rack arrangements	CLO15	T1-10.16
58-59	Introduction to Helical, Bevel and worm gearing.	CLO16	T1-10.20, R4-10.22
60-61	Gear trains-Introduction – Types – Simple and reverted gear trains	CLO17	T1- 11.1, R2-11.2
62-63	Epicyclic gear train.Methods of finding train value or velocity ratio of Epicyclic gear trains.	CLO19	T1- 11.6, R2-11.7
64-65	Selection of gear box-Differential gear for an automobile.	CLO20	T1-11.12,R3-11.12

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

S No	Description	Proposed actions	Relevance with POs	Relevance with PSOs
1	Design of coupler curves for four bar mechanism and slider crank mechanism	Seminars	PO 1, PO 4	PSO 1
2	Design and development of differential gear box for an automobile negotiating a turn	Seminars / NPTEL	PO 4, PO3	PSO 1
3	Synthesis of mechanisms	NPTEL	PO 2	PSO 1

S No	Description	Proposed actions	Relevance with POs	Relevance with PSOs
	using Frudenstein's equation using Chebyshev spacing			

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