INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad -500 043

MECHANICAL ENGINEERING
COURSE DESCRIPTOR

Course Title	**KINEMATICS OF MACHINES**				
Course Code	**AMEB10**				
Program	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. B.V. S. N. Rao, Associate Professor,				
Course Faculty	Mr. V.V.S.H. Prasad, Associate Professor				

I. COURSE OVERVIEW:

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

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
UG	AMEB03	II	Engineering Mechanics

III. MARKS DISTRIBUTION

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 modules and each module carries equal weight 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**: 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
PO 2	**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
PO 3	**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	Term Paper

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 professionals Capable of synthesizing and analyzing mechanical systems including allied engineering streams.	2	Presentation on real-world problems
PSO 2	**Modeling and Simulation Practices:** 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 :

The course should enable the students to:	
I	To understand the mechanisms of various machines in order to find the velocity and accelerations for ideation of product development
II	Understand the basic principles of kinematics and the related terminology of machines.
III	Discriminate mobility; enumerate links and joints in the mechanisms.
IV	Formulate the concept of analysis of different mechanisms.
V	Understand the working of various straight line mechanisms, gears, gear trains, steering gear mechanisms, cams and a Hooke‟s joint.
VI	Analyze a mechanism for displacement, velocity and acceleration of links in a machine.

IX. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Understand designing a suitable mechanism depending on application	CLO 1	Classifications of 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 quadric cycle chain.
		CLO 4	Design and develop inversions of slider crank mechanism.
CO 2	Understand displacement diagrams and cam profile diagram for followers executing different types of motions and various configurations of followers.	CLO 5	Construct Graphical methods of velocity and acceleration polygons for a given configuration diagram.
		CLO 6	Understand other methods of acceleration determination diagrams like Klien's construction.
		CLO 7	Develop acceleration component of Corioli's acceleration involving quick return mechanisms
CO 3	Visualize drawing velocity and acceleration diagrams for different mechanisms.	CLO 8	Alternative approach for determining velocity by using Instantaneous centers and relative velocity methods.
		CLO 9	Significance of exact and approximate straight line mechanisms.
		CLO 10	Application of straight line mechanism in engine indicators.
		CLO 11	Applications of Ackerman's and Davis steering mechanisms in automobiles.
CO 4	Select gear and gear train depending on application	CLO 12	Develop the condition for exact steering.
		CLO 13	Develop the polar velocity diagram for a single Hook joint and develop condition for unity for higher and lower speeds.
		CLO 14	Study different displacement diagrams applicable in cams.
CO 5	Explore the knowledge on differential gear design.	CLO 15	Plot the displacement, velocity and acceleration diagrams with respect to time.
		CLO 16	Understand the geometry of gears and deduce the expression for arc of contact.
		CLO 17	Derive the expression for minimum number of teeth to avoid interference in case of pinion and gear.

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
AMEB10.01	CLO 1	Classifications of the kinematic links, kinematic pairs and formation of the kinematic chain.	PO 1	3
AMEB10.02	CLO 2	Distinguish between mechanism and machine	PO 2	2
AMEB10.03	CLO 3	Design and develop inversions of quadratic cycle chain.	PO 1	3
AMEB10.04	CLO 4	Design and develop inversions of slider crank mechanism.	PO 1	3
AMEB10.05	CLO 5	Construct Graphical methods of velocity and acceleration polygons for a given configuration diagram.	PO 2	3
AMEB10.06	CLO 6	Understand other methods of acceleration diagrams like Klien's construction.	PO 2	2
AMEB10.07	CLO 7	Develop acceleration component of Corioli's acceleration involving quick return mechanisms.	PO 2	3
AMEB10.08	CLO 8	Alternative approach for determining velocity by using Instantaneous centers and relative velocity methods.	PO 2	2
AMEB10.09	CLO 9	Significance of exact and approximate straight line mechanisms.	PO 3	1
AMEB10.10	CLO 10	Application of straight line mechanism in steam engine indicators.	PO 3	1
AMEB10. 11	CLO 11	Applications of Ackerman's and Davis steering mechanisms in automobiles.	PO 2	2
AMEB10. 12	CLO 12	Develop the condition for exact steering.	PO 2	2
AMEB10. 13	CLO 13	Develop the polar velocity diagram for a single Hook joint and develop condition for unity for higher and lower speeds.	PO 1	2
AMEB10. 14	CLO 14	Study different displacement diagrams applicable in cams.	PO 3	2
AMEB10. 15	CLO 15	Plot the displacement, velocity and acceleration diagrams with respect to time.	PO 1	3
AMEB10. 16	CLO 16	Understand the geometry of gears and deduce the expression for arc of contact.	PO 1, PO 2	3
AMEB10. 17	CLO 17	Derive the expression for minimum number of teeth to avoid interference in case of pinion and gear.	PO 1,PO 2	3

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

Course Outcomes (COs)	Program Outcomes (POs)			
	PO 1	PO 2	PO 3	PSO1
CO 1	3	2		1
CO 2		2		
CO 3		2	1	
CO 4	2	2	2	1
CO 5	3	2		1

3 = High; 2 = Medium; 1 = Low

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

3 = High; 2 = Medium; 1 = Low

XIII. ASSESSMENT METHODOLOGIES – DIRECT

CIE Exams	PO1, PO2, PO3, PSO1	SEE Exams	PO1, PO2, PO3, PSO1	Assignments	-	Seminars	PO1, PO2, PO3,PSO 1
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	PO1, PO2, PO3, PSO 1						

XIV. ASSESSMENT METHODOLOGIES - INDIRECT

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

XV. SYLLABUS

Module-I	**MECHANISMS**	**Classes: 10**
Mechanisms: Elements or links, classification, rigid link, flexible and fluid link, types of kinematic pairs types of constrained motion, kinematic chain, mechanism, machine, structure, inversion of mechanism, inversions of quadric cycle chain, single and double slider crank chains, mechanical advantage, Grubler's Criterion.		
Module-II	**KINEMATICS, PLANE MOTION OF BODY, ANALYSIS OF MECHANISMS**	**Classes: 09**
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. Kleins 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.		
Module-III	**STRAIGHT LINE MOTION MECHANISMS, STEERING GEARS, HOOKE'S JOINT**	**Classes: 10**
Straight-line motion Mechanisms: Exact and approximate copied and generated types, Peaucellier, Hart and Scott Russell, 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.		
Module-IV	**CAMS, ANALYSIS OF MOTION OF FOLLOWERS**	**Classes: 08**
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.		
Module-V	**HIGHER PAIRS, GEAR TRAINS**	**Classes: 08**
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. Jagadishlal, "Theory of Mechanisms and Machines", Metropolitan Book Company, 1st Edition, 1978. 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.

XVI. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

Lecture No	Topic/s to be covered	Course Learning Outcomes (CLOs)	Reference
1	**MODULE-I: MECHANISMS:** Kinematics of machinery –introduction, link- rigid link, flexible and fluid link	CLO 1	R2-1.1 , 1.3
2	Types of kinematic pairs.	CLO 1	R2-1.4 and 1.7
3	Types of constrained motion-kinematic chain,	CLO 2	R2- 1.2.
4	Mechanism, machine and structure.	CLO 2	R2-1.8,1.9
5	Inversion of mechanism – inversions of quadric cycle chain.	CLO 2	R2- 1.15,
6	Inversion of mechanism – single and double slider crank chain.	CLO 2	R2-1.16
7	Mechanical advantage and Grubler's criterion	CLO 3	R2- 1.6
8	**MODULE II- KINEMATICS, PLANE MOTION OF BODY, ANALYSIS OF MECHANISMS** Velocity of link in machine, vector diagram for velocity.	CLO 3	R2- 2.2, 2.6
9	Determination of velocity using graphical method.	CLO 3	R2-2.6, 2.10
10	Determination of velocity by relative velocity method.	CLO 3	R2-2.6, 2.10
11	Acceleration of link in machine, vector diagram for determining acceleration.	CLO 4	R2-3.2, 3.3,
12-14	Determination of acceleration using graphical method.	CLO 4	R2-3.5
15-16	Instantaneous center of rotation, centroids, axodes and three centers in line theorem.	CLO 4	R2-2.13, 2.14and 2.16
17-18	Graphical determination of instantaneous center, determination of angular velocity of points and links by instantaneous center method.	CLO 4	R2-2.15
19-20	Klein's construction and determination of Corioli's component of acceleration.	CLO 5	R2-3.9, 3.6
21-22	**MODULE III -STRAIGHT LINE MOTION MECHANISMS, STEERING GEARS, HOOKE'S JOINT** Exact and approximate, copied and generated types Straight line mechanisms- Peaucellier, Hart, Scott Russel and Grasshopper mechanisms	CLO 5	R2-6.1, 6.3
23-24	Watt's, Tchebicheff 's and Robert's mechanisms - pantograph.	CLO 5	R2-6.2, 6.3
25	Conditions for correct steering – Davis steering gear.	CLO 5	R2-6.5, 6.6
26	Conditions for correct steering: Ackermann steering gear.	CLO 5	R2-6.5, 6.6
27	Single Hooke's joint – Velocity ratio – application – problems.	CLO 5	R2-6.7, 6.8
28	Double Hooke's joint – Velocity ratio – application – problems.	CLO 5	R2-6.7, 6.8

29	**MODULE IV -CAMS, ANALYSIS OF MOTION OF FOLLOWERS** **CAMS:** Definitions of cam and followers, their uses.	CLO 6	R2-7.1
30	Types of followers and cams, terminology.	CLO 6	R2- 7.2,
31	Types of follower motion.	CLO 6	7.3 and 7.4
32	Uniform velocity, simple harmonic motion.	CLO 6	R2- 7.9
33-34	Uniform acceleration and retardation.	CLO 6	R2-7.9, 7.10
35-36	Maximum velocity and maximum acceleration during outward and return strokes in the three cases.	CLO 6	R2-7.9, 7.10
37	Analysis of motion of followers: Tangent cam with roller follower,	CLO 6	R2- 7.11
38	Analysis of motion of followers: circular arc cam with straight flanks.	CLO 6	R2- 7.11
39	Analysis of motion of followers: circular arc cam with concave and convex flanks.	CLO 6	R2- 7.11
40	**MODULE V- HIGHER PAIRS, GEAR TRAINS** Friction wheels and toothed gears and types of gears.	CLO 7	R2- 10.1, 10.2, 10.3
41-42	Law of gearing -Condition for constant velocity ratio for transmission of motion - velocity of sliding.	CLO 7	R2-10.4, 10.5
43	Form of teeth- cycloidal and involute profiles	CLO 7	R2-10.6, 10.7, 10.8
44	Phenomena of interference – Methods of interference.	CLO 7	R2- 10.14 and 10.15
45	Condition for minimum number of teeth to avoid interference	CLO 7	R2- 10.14 and 10.15
46-47	Expressions for arc of contact and path of contact of pinion & gear	CLO 7	R2-10.11
48	Pinion and rack arrangements in transmission of motion.	CLO 8	R2-10.16
49-50	Introduction to helical, bevel and worm gearing.	CLO 8	R2-10.20, 10.22, 10.23,10.26
51	Gear trains-Introduction – Types – Simple and reverted gear trains.	CLO 8	R2- 11.1, 11.2, 11.3, 11.4
52-54	Epicyclic gear train, Methods of finding train value or velocity ratio of epicyclic gear trains.	CLO 8	R2- 11.6, 11.7, 11.10
55-56	Selection of gear box-Differential gear for an automobile.	CLO 5	R2-11.12

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

S NO	Description	Proposed actions	Relevance with POs	Relevance with PSOs
1	Design of four bar mechanism and slider crank mechanism	Guest Lecture	PO 1	PSO 1
2	Design and development of differential gear box for an automobile.	Seminar/ Guest Lecture	PO 3	PSO 1
3	Selection of gear box in transmission of motion.	Guest Lecture	PO 2	PSO 1

Prepared by:

Mr. B. V. S. N. Rao, Professor,

HOD, ME