INSTITUTE OF AERONAUTICAL ENGINEERING

Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTION

Course Title	**KINEMATICS OF MACHINERY**			
Course Code	**A40309**			
Regulation	**R13**			
Course Structure	Lectures	Tutorials	Practicals	Credits
	4	1	-	4
Course Coordinator	Prof V V S H Prasad, Professor			
Team of Instructors	Prof. V V S H Prasad, Professor, G.Karunya, Asst.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 analise 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. PREREQUISITE(S):

Level	Credits	Periods / Week	Prerequisites
UG	4	5	Engineering Mechanics, Engineering Mathematics, Engineering drawing

III. MARKS DISTRIBUTION:

Sessional Marks (25)	University End Exam Marks	Total Marks
Continuous Assessment Tests (Midterm examinations): There shall be 2 midterm examinations. Each midterm examination consists of one objective paper, one subjective paper and four assignments. The objective paper is for 10 marks and subjective paper is for 10 marks, with duration of 1 hour 20 minutes (20 minutes for objective and 60 minutes for subjective paper). Objective paper is set for 20 bits of – multiple choice questions, fill-in the blanks, 10 marks. Subjective paper contains of 4 full questions (one from each unit) of which, the student has to answer 2 questions, each question carrying 5 marks. First midterm examination shall be conducted for 2.5 units of syllabus and second midterm examination shall be conducted for another 2.5 units. 5 marks are allocated for Assignments. First two assignments should be submitted before the conduct of the first mid, and the second two assignments should be submitted before the conduct of the second mid. The total marks secured by the student in each midterm examination are evaluated for 25 marks, and the average of the two midterm examinations shall be taken as the final marks secured by each candidate.	75	100

IV. EVALUATION SCHEME:

S. No.	Component	Duration	Marks
1	I Mid Examination	1 hour and 20 min	20
2	I Assignment lot		5
		TOTAL	**25**
3	II Mid Examination	1 hour and 20 min	20
4	II Assignment lot		5
		TOTAL	**25**
MID Examination marks to be considered as average of above 2 MID's TOTAL			
5	EXTERNAL Examination	3 hours	75
		GRAND TOTAL	**100**

V. COURSE OBJECTIVES:

The objectives of the course are to enable the student;

I. To 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. To understand the working of various straight line mechanisms, gears, gear trains, steering gear mechanisms, cams and Hooke's joint.

V. Analyze a mechanism for displacement, velocity and acceleration of links in a machine.

VI. COURSE OUTCOMES:

On successful completion of the course, the student will be able to

1. Be familiar with different machine elements which accomplish similar results.
2. Calculate mobility and enumerate rigid links and types of joints in mechanisms.
3. Able to create a schematic drawing of real world mechanisms.
4. Able to conduct a complete translational and rotational mechanism for the velocity and acceleration analysis.
5. Able to design mechanisms of basic cam systems for different machinery.

VII. HOW COURSE OUTCOMES ARE ASSESSED:

Program Outcomes		Level	Proficiency assessed by
a	An ability to apply knowledge of mathematical foundations, mechanical engineering theory in the modeling and design of mechanical based systems to real-world problems (fundamental engineering analysis skills)	H	Assignments Midterm and University examinations, Practicals
b	An ability to design and conduct experiments, as well as to analyze and interpret data (information retrieval skills)	H	Assignments Midterm and University examinations, Practicals
c	An ability to design , implement, and evaluate a computer-based system, process, component, or program to meet desired needs, within realistic constraints such as economic, environmental, social, political, health and safety,	S	Assignments Midterm and University examinations, Practicals

Program Outcomes		Level	Proficiency assessed by
	manufacturability, and sustainability (Creative Skills)		
d	An ability to function effectively on multi-disciplinary teams (team work)	N	--
e	An ability to analyze a problem, identify, formulate and use the appropriate computing and engineering requirements for obtaining its solution (engineering problem solving skills)	H	Assignments Midterm and University examinations, Practicals
f	An understanding of professional, ethical, legal, security and social issues and responsibilities (professional integrity)	N	--
g	An ability to communicate effectively both in writing and orally (speaking / writing skills)	N	--
h	The broad education necessary to analyze the local and global impact of computing and engineering solutions on individuals, organizations, and society (engineering impact assessment skills)	N	--
i	Recognition of the need for, and an ability to engage in continuing professional development and life-long learning (continuing education awareness)	H	Assignments Midterm and University examinations, Practicals
j	A Knowledge of contemporary issues (social awareness)	N	--
k	An ability to use current techniques, skills, and tools necessary for computing and engineering practice (practical engineering analysis skills)	S	Assignments Midterm and University examinations, Practicals
l	An ability to apply design and development principles in the construction of software and hardware systems of varying complexity (software hardware interface)	N	--
m	An ability to recognize the importance of professional development by pursuing postgraduate studies or face competitive examinations that offer challenging and rewarding careers in computing (successful career and immediate employment).	N	--

VIII. SYLLABUS:

UNIT-I

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.

UNIT - II

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.

UNIT – III

STRAIGHT-LINE MOTION MECHANISMS : Exact and approximate copied and generated types – Peaucellier - Hart and Scott Russul – Grasshopper – Watt -T. Chebicheff and Robert Mechanisms - Pantograph.

STEERING GEARS: Conditions for correct steering – Davis Steering gear, Ackermans steering gear.

HOOKE'S JOINT: Single and double Hooke's joint – Velocity Ratio – application – problems.

UNIT – IV

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 3 cases.

ANALYSIS OF MOTION OF FOLLOWERS: Tangent cam with Roller follower – circular arc cam with straight, concave and convex flanks.

UNIT – V

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 & 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. Theory of Machines and Mechanisms/ JOSEPH E. SHIGLEY/ Oxford/ 3rd Edition
2. Theory of machines/ Thomas Bevan/ Pearson/ 3rd Edition,

REFERENCES BOOKS:

1. Theory of Mechanisms and Machines/ Jagadish Lal
2. Theory of Machines / S.S. Rattan/ Tata McGraw-Hill education
3. Kinematics and dynamics of machinery/ Norton/ Tata McGraw-Hill education
4. Theory of Machines/ Sadhu Singh/ Pearson
5. Mechanisms and Machine Theory / JS Rao and RV Duggipati
6. Theory of machines/ R. K. Bansal/ Lakshmi Publications

IX. COURSE PLAN:

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

Lecture No.	Course Learning Outcomes	Topics to be covered	Reference
	UNIT 1		
1-2	**Define** Kinematics Of Machinery, Link and Pair **Classify** Links and Pairs	Kinematics of Machinery -Introduction Link- Rigid Link, flexible and fluid link Types of kinematic pairs	R2-1.1 , 1.31.4 and 1.7
3-4	**Define** kinematic chain, Mechanism, Machine and Structure. **Classify** constrained motion	Types of constrained motion. kinematic chain , Mechanism, Machine and Structure	R2-1.2,1.8,1.9
5-6	**Explain** Inversion of different mechanism	inversion of mechanism – inversions of quadric cycle chain, single and double slider crank chains	R2- 1.15, 1.16
7-8	**Discuss** Grubler's Criterion	Mechanical Advantage and Grubler's	R2- 1.6

	Calculate problems on degree of freedom	Criterion	
UNIT II			
9-10	**Define** Velocity of link **Explain** Velocity Diagram **Construct** Velocity Diagram for a mechanism	Velocity of link in machine, Vector diagram for velocity.	R2- 2.2, 2.6
11-12	**Calculate** problems on velocity	Determination of Velocity using Graphical method using relative velocity method.	R2-2.6, 2.10
12	**Define** Acceleration of link **Explain** Acceleration Diagram	Acceleration of link in machine, Vector diagram for Acceleration.	R2-3.2, 3.3,
13-14	**Construct** Acceleration Diagram **Calculate** problems on Acceleration	Determination of Acceleration using Graphical method	R2-3.5
15-16	**Define** Instantaneous center, centroids and axodes **Explain** Three centers theorem	Instantaneous center of rotation, centroids & axodes and Three centers in line theorem.	R2-2.13, 2.14and 2.16
17-18	**Identify** instantaneous center **Calculate** problems on instantaneous center method	Graphical determination of instantaneous center, determination of angular velocity of points and links by instantaneous center method	R2-2.15
23-24	**Explain** Kliens construction, corolis component.	Kleins construction, Coriolis acceleration and determination of Coriolis component of acceleration.	R2-3.9, 3.6
UNIT III			
25-27	**Explain** Exact and approximate straight line mechanisms **Discuss** Peaucellier, Hart, Scott Russul and Grasshopper mechanism **Design** straight line mechanisms	Exact and approximate copied and generated types straight line mechanisms Peaucellier, Hart, Scott Russul and Grasshopper mechanisms	R2-6.1, 6.3
27-28	**Discuss** Watt,T. Chebicheff and Robert Mechanisms, Pantograph. **Design** straight line mechanisms	Watt -T. Chebicheff and Robert Mechanisms - Pantograph.	R2-6.2, 6.3
29-30	**Explain** Conditions for correct steering **Discuss** Davis Steering gear, Ackermans steering gear.	Conditions for correct steering – Davis Steering gear, Ackermans steering gear.	R2-6.5, 6.6
33-34	**Explain** Hooke's joints **Solve** velocity ratio problems	Single and double Hooke's joint – Velocity Ratio – application – problems.	R2-6.7, 6.8
UNIT IV			
37-38	**Define** cam and follower **Discuss** uses of cam and follower	**CAMS:** Definitions of cam and followers, their uses	R2-7.1
39-40	**Classify** cams and follower and follower motion	Types of followers and cams, Terminology, Types of follower motion,	R2- 7.2, 7.3 and 7.4
41-42	**Explain** Uniform velocity, Simple harmonic motion **Construct** Cam profiles for Uniform velocity, Simple harmonic motion	Uniform velocity, Simple harmonic motion	R2- 7.9
43-44	**Explain** uniform acceleration in cams	Uniform acceleration. Maximum velocity and maximum acceleration during outward	R2-7.9, 7.10

	Construct cam profiles for Maximum velocity and maximum acceleration	and return strokes in the above 3 cases.	
45-46	**Explain** Roller follower, straight concave and convex flanks followers **Construct** cam profiles for Roller follower, straight concave and convex flanks followers	Analysis of motion of followers: Tangent cam with Roller follower, circular arc cam with straight concave and convex flanks	R2- 7.11
UNIT V			
47-48	**Explain** Gear and friction wheels **Classify** gears	Friction wheels and toothed gears and types of gears	R2- 10.1, 10.2, 10.3
49-50	**Explain** law of gearing **Discuss** constant velocity ratio and Velocity of sliding. **Solve** problems on constant velocity ratio and Velocity of sliding.	law of gearing -Condition for constant velocity ratio for transmission of motion - Velocity of sliding.	R2-10.4, 10.5
51	**Explain** cycloidal and involute profiles	Form of teeth, cycloidal and involute profiles	R2-10.6, 10.7and 10.8
52-53	**Discuss** interferences, condition for minimum number of teeth. **Solve** problems on interference	Phenomena of interferences – Methods of interference. Condition for minimum number of teeth to avoid interference	R2- 10.14 and 10.15
54-55	**Explain** arc of contact and path of contact **Solve** problems on arc of contact and path of contact	expressions for arc of contact and path of contact of Pinion & Gear	R2-10.11
56-57	**Explain** Pinion and Rack arrangements **Solve** problems on Pinion and Rack arrangements	Pinion and Rack arrangements	R2-10.16
58-59	**Define** Helical, Bevel and worm gears **Explain** Helical, Bevel and worm gears **Solve** problems on Helical, Bevel and worm gears	Introduction to Helical, Bevel and worm gearing.	R2-10.20, 10.22, 10.23,10. 26 and 10.27
60-61	**Explain** Gear Trains **Classify** Gear Trains **Solve** problems on Simple and reverted gear trains **Analyze** Simple and reverted gear trains.	Gear trains-Introduction – Types – Simple and reverted gear trains	R2- 11.1, 11.2, 11.3, 11.4and 11.5
62-63	**Explain** velocity ratio of Epicyclic gear trains **Solve** problems on velocity ratio of Epicyclic gear trains	Epicyclic gear train. Methods of finding train value or velocity ratio of Epicyclic gear trains.	R2- 11.6, 11.7, 11.10
64-65	**Discuss** differential gear of an automobile.	Selection of gear box-Differential gear for an automobile.	R2-11.12

X. MAPPING COURSE OBJECTIVES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

Course Objectives	Program Outcomes												
	A	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**m**
I	S				H								
II			S		H						S		
III		H							S				
IV	H		S								H		
V			S		H								

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

Course Outcomes	Program Outcomes												
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**m**
1				S		H							
2			H						S				
3					H						S		
4			S			H							
5			S	H							S		
6		H			H							S	

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