INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING

COURSE DESCRIPTION FORM

Course Title	**MECHANISMS AND MECHANICAL DESIGN**			
Course Code	**A72123**			
Regulation	**R13-JNTUH**			
Course Structure	**Lectures**	**Tutorials**	**Practical's**	**Credits**
	4	-	-	4
Course Coordinator	Dr. D Govardhan, Professor			
Team of Instructors	Mr. B Naveen kumar, Assistant Professor			

I. COURSE OVERVIEW

Mechanical devices are designed to have mobility to perform certain functions. The theory behind the study of MMD 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 course will provide the knowledge on how to analyze the forces acting on various parts of machines and design machines to give required output. This includes relative force analysis and calculation of gyroscopic couples, analyzing forces 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	Prerequisite
UG	4	4	Engineering mechanics, mathematics and drawing

III. MARKS DISTRIBUTION

Sessional Marks	University End Exam Marks	Total Marks
Mid Semester Test There shall be two midterm examinations. Each midterm examination consists of subjective type and objective type tests. The subjective test is for 10 marks of 60 minutes duration. Subjective test of shall contain 4 questions; the student has to answer 2 questions, each carrying 5 marks. The objective type test is for 10 marks of 20 minutes duration. It consists of 10 Multiple choice and 10 objective type questions, the student has to answer all the questions and each carries half mark. First midterm examination shall be conducted for the first two and half units of syllabus and second midterm examination shall be conducted for the remaining portion. **Assignment** Five marks are marked for assignments. There shall be two assignments in every	75	100

theory course. Marks shall be awarded considering the average of two assignments in each course		

IV. EVALUATION SCHEME

S No	Component	Duration	Marks
1	I Mid examination	80 minutes	20
2	I Assignment	--	05
3	II Mid examination	80 minutes	20
4	II Assignment	--	05
5	External examination	3 hours	75

V. COURSE OBJECTIVES:

i. **Understand** the basic principles of kinematics and the related terminology of machines.
ii. **Discuss** 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 Hooke's joint.
v. **Analyze** a mechanism for displacement, velocity and acceleration of links in a machine.
vi. **Understand** the basic principles of dynamics and to determine the forces acting on machines

VI. COURSE OUTCOMES

After completing this course the student must demonstrate the knowledge and ability to:

1. **Understand** different machine elements which accomplish similar results.
2. **Calculate** mobility and enumerate rigid links and types of joints in mechanisms.
3. **Understand** schematic drawing of real world mechanisms.
4. **Analyze** complete translational and rotational mechanism for the velocity and acceleration analysis.
5. **Evaluate** forces and analyze for the design of machine components.
6. **Explain** measure precession measurements
7. **Apply** the concept of design gears with required velocity ratio

VII. 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 engineering.	H	Assignments
PO2	**Problem analysis**: An ability to analyze complex engineering problems to arrive at relevant conclusions using knowledge of Mathematics, Science and Engineering.	S	Exercise
PO3	**Design/development of solutions**: Competence to design a system, com ponent or process to meet societal needs within realistic constraints.	S	Assignments, Discussion
PO4	**Conduct investigations of complex problems**: To design and conduct research oriented experiments as well as to analyze and implement data using research methodologies.	H	Exercise
PO5	**Modern tool usage**: An ability to formulate, solve complex engineering problems using modern engineering and Information Technology tools.	S	------
PO6	**The engineer and society**: To utilize the Engineering practices, Techniques, skills to meet needs of the health, safety, legal, cultural and societal issues.	H	Exercise
PO7	**Environment and sustainability**: To understand impact of Engineering solutions in the societal context and demonstrate the knowledge for sustainable development.	S	Discussion, Seminars

PO8	**Ethics**: An understanding and Implementation of professional and Ethical responsibilities.	S	Discussion, Seminars
PO9	**Individual and teamwork**: To function as an effective individual and as a member or leader in Multi-disciplinary environment and adopt in diverse teams.	H	Discussions
PO10	**Communication**: An ability to assimilate, comprehends, communicate, give and receive instructions to present effectively with engineering community and society.	H	Discussion, Seminars
PO11	**Project management and finance**: An ability to provide leadership in managing complex engineering projects at Multidisciplinary environment and to become a professional engineer.	H	-----
PO12	**Life-long learning**: Recognition of the need and an ability to engage in life-long learning to keep abreast with technological changes.	H	Prototype, Discussions

S – Supportive **H – Highly Related**

VIII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED

Program Specific Outcomes		Level	Proficiency assessed by
PSO1	**Professional Skills:** An ability to understand the basic concepts in Electronics & Communication Engineering and to apply them to various areas, like Electronics, Communications, Signal processing, VLSI, Embedded systems etc., in the design and implementation of complex systems.	H	Lectures and Assignments
PSO2	**Problem-solving skills:** An ability to solve complex Electronics and communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.	S	Tutorials
PSO3	**Successful career and Entrepreneurship:** An understanding of social-awareness & environmental-wisdom along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an Entrepreneur.	S	Seminars and Projects
PSO4	**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	H	Assignment

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IX. SYLLABUS

UNIT – I

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. Kinematic chain, inversion of mechanism, inversion of quadratic cycle. Chain – single and double slider crank chains. Exact and approximate straight line mechanisms - Peaucellier, Hart T. Chibichef, Pantograph. Steering gear mechanisms: Condition for correct steering – Davis steering gear, Ackerman's steering gear-Hook's joint: single and double Hooks joint, applications.

UNIT – II

KINEMATIC ANALYSIS : 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. Instantaneous centre of rotation, centroids and axodes – Relative motion between two bodies – Three centres in line theorem – Graphical determination of instantaneous centre, diagrams for simple mechanisms and determination of angular velocity of points and links.

Kinematic Design: Four bar mechanism, Freudenstein equation. Precession point synthesis, Chebyshev's method, structural error

UNIT – III

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- 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.

UNIT – V

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.

TEXT BOOKS:

1. Theory of Mechanisms and machines, Amithab Ghosh and Asok Kumar Malik, East West Press Pvt.LTD-2001.
2. Mechanism and Machine Theory, JS Rao and RV Dukkipati / New Age – 1996.

REFERENCES:

1. Theory of Machines, Dr Jagdish Lal, JM Shaw.
2. Theory of Machines, Abdulla Sharif, Dhanpat Rai, 1987.
3. Theory of Machines, PL Ballaney, Khanna Publishers, 2003.
4. Theory of Machines Through Solved Problems, JS Rao / New Age – 1996
5. Mechanical engineering and design, J.E.Shigley and Charles.R.Mischke, TMH, 2003.

X. 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
1-2	**Define** Kinematics Of Machinery, Link and Pair **Classify** Links and Pairs.	Kinematics of Machinery –Introduction to Link- Rigid Link, flexible and fluid link Types of kinematic pairs.	T1:1.1
3-4	**Define** kinematic chain, Mechanism, Machine and Structure **Classify** constrained motion	Types of constrained motion. kinematic chain , Mechanism, Machine and Structure.	T1:1.1
5-6	**Explain** Inversion of different mechanism	inversion of mechanism – inversions of quadric cycle chain, single and double slider crank chains.	T1:1.1-1.5
7-8	**Discuss** Grubler's Criterion **Calculate** problems on degree of freedom.	Mechanical Advantage and Grubler's Criterion.	T1:1.6
9-10	**Define** Velocity of link **Explain** Velocity Diagram **Construct** Velocity Diagram for a mechanism.	Velocity of link in machine, Vector diagram for velocity.	T1:1.1
11	**Calculate** problems on velocity	Determination of Velocity using Graphical method using relative velocity method.	T1:2.1
12-13	**Define** Acceleration of link. **Explain** Acceleration Diagram	Acceleration of link in machine, Vector diagram for Acceleration.	T1:1.2-1.4
14-15	**Construct** Acceleration Diagram **Calculate** problems on Acceleration	Determination of Acceleration using Graphical method	T1:2.5
16-17	**Define** Instantaneous center, centroids and axodes **Explain** Three centers theorem	Instantaneous center of rotation, centroids & axodes and Three centers in line theorem.	T1:2.5-2.6
18	**Identify** instantaneous center **Calculate**	Graphical determination of instantaneous	T1:2.6

	problems on instantaneous center method.	center, determination of angular velocity of points and links by instantaneous center method.	
19-20	**Explain** Kliens construction, corolis component.	Kleins construction, Coriolis acceleration and determination of Coriolis component of acceleration.	T1:2.5-2.6
21-22	**Define** precession	Gyroscopes, angular motion	T1:4.1
23-24	**Define** spin vector **Discuss the effect of precession on stability** of moving vehicles	Stability of car, motor cycle, ship and aero plane considering gyroscopic effect	T1:4.2-4.8
25-26	**Explain** the three perpendicular directions of spin vector,precession vector and gyroscopic couple	Determination of Gyroscopic couple magnitude and direction.	T1:4.1-4.8
27-28	**Define** cam and follower **Discuss** uses of cam and follower	**CAMS:** Definitions of cam and followers, their uses	T1:4.1-4.8
29-30	**Classify** cams and follower and follower motion	Types of followers and cams, Terminology, Types of follower motion	T1:4.1-4.8
31-32	**Explain** Uniform velocity, Simple harmonic motion **Construct** Cam profiles for Uniform velocity, Simple harmonic motion	Uniform velocity, Simple harmonic motion	T1:4.1-4.8
33-34	**Explain** uniform acceleration in cams **Construct** cam profiles for Maximum velocity and maximum acceleration	Uniform acceleration. Maximum velocity and maximum acceleration during outward and return strokes in the above 3 cases.	T1:4.1-4.8
35-36	**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	T1: 4.1-4.8
37-38	**Explain** Gear and friction wheels **Classify** gears	Friction wheels and toothed gears and types of gears	T1: 4.1-4.8
39-40	**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.	T1:4.10
41-42	**Explain** cycloidal and involute profiles.	Form of teeth, cycloidal and involute profiles	T1: 4.1-4.8
43-44	**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	T1:4.8
45-46	**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.	T1:11.1
47-48	**Explain** Pinion and Rack arrangements **Solve** problems on Pinion and Rack arrangements.	Pinion and Rack arrangements	T1:11.2
49-50	**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.	T1:11.7
51-55	**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	T1:11.5
56-60	**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.	T1:15.1-15.5
60-65	**Discuss** differential gear of an automobile.	Selection of gear box-Differential gear for an automobile.	T1:

XI. MAPPING COURSE OBJECTIVES LEADING TO THE ACHIEVEMENT OF THE PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

Course Objectives	Program Outcomes												Program Specific Outcomes			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
I	S		H	S		S	S		S	S		H	H	H	S	
II	H		H	H	H	H	S	H	S	S	H	H	H	H	S	
III	S	H	H	H		H	S	H	S	S		H	S	S	S	
IV	S	S	H	H	S	S	S		S	S	S	H	S	H	S	
V	H		H	S		H	S		S	S		H	S	S	S	

S – Supportive **H - Highly related**

XII. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

Course Outcomes	Program Outcomes												Program Specific Outcomes			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
1	S		H	S		S	S	S	S			S	S	S	S	
2	H		H	H		H		S	S		S	S	S	S	S	
3		S	H			H			S	S	S	S		H		
4		S	H			S	S		S	S		S		H	H	
5	H		H	S	H		S	H	S	S	H	S	S	S	H	
6	S		H	S	H		S	H	S	S	H	S	S	S		
7	S		H	S		H	S		S	S		S		S	S	

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