INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad -500 043

MECHANICALENGINEERING

COURSE DESCRIPTOR

Course Title	DYNAMICS OF MACHINERY				
Course Code	AME011				
Programme	B.Tech				
Semester	V	ME			
Course Type	Core				
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:

This course focuses on mechanical devices that are designed to have mobility to perform certain functions. In this process they are subjected to some forces. The study of Dynamics of machinery leads us to design machines by understanding the relationship between the movement of various parts of machine and the different forces that are acting on them. This course will provide the knowledge on how to analyze the motions of mechanisms and design mechanisms to give required strength. This includes relative static and dynamic force analysis and consideration of gyroscopic effects on aero planes, ships, automobiles like two wheelers and four wheelers.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AME009	IV	Kinematics of Machinery	4
UG	AME001	I	Engineering Drawing	4

III. MARKSDISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Dynamics of machinery	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 and MOOCs.

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	Seminars
PO 4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	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 professional capable of synthesizing and analyzing mechanical systems including allied engineering streams.	1	Seminar
PSO 2	**Problem solving skills**: 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 (COs):

The course should enable the students to:	
I	Understand the concept of equilibrium of a body subjected to static and dynamic forces.
II	Apply the phenomenon of friction for automobile application.
III	Analyze the significance of governors and its application in turning moment diagram.
IV	Determine the fundamental frequency of mechanical system.

IX. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Understand the equilibrium of a body subjected to static and dynamic forces of various mechanisms.	CLO 3	Understand static force analysis of mechanisms.
		CLO4	Understand dynamic force analysis of mechanisms

COs	Course Outcome	CLOs	Course Learning Outcome
CO 2	Understand the concept of gyroscopic effect in aero-planes, ships and automobiles for stabilization.	CLO 1	Understand dynamic analysis like gyroscopic forces and moments, rotation of rigid bodies.
		CLO 2	Understand the gyroscopic effect on ships, planes and road vehicles.
CO 3	Explore the concept of friction in various contacts of bodies.	CLO 5	Determine the dynamic behavior principle and operations of clutches, brakes, dynamometers.
		CLO 6	Compute frictional losses, torque transmission of mechanical systems such as clutches, brakes.
		CLO 7	Compute frictional losses, torque transmission of mechanical systems such as dynamometers.
		CLO 8	Understand the design of centrifugal governors.
		CLO9	Determine the dynamic behavior principles and operations of flywheels and governors.
CO 4	Understand the significance of energy storage devices by studying the TMD.	CLO 10	Determine the dynamic behavior principles and operations of flywheels and governors.
		CLO 11	Determine the dynamic behavior principles and operations of flywheels and governors.
		CLO 13	Determine the dynamic behavior principles and operations of flywheels and governors.
		CLO 14	Determine the dynamic behavior principles and operations of flywheels and governors.
CO 5	Explore the equations of motion of various degree of freedom systems.	CLO15	Apply the different methods to solve the equation of motion in damped forced vibrations.
		CLO16	Understand the concepts of free and forced vibrations of single degree freedom systems.
		CLO 17	Remember the concepts of vibration modes and natural frequencies and their measurement and estimation for multi-degree-of-freedom systems.
		CLO 18	Interpret the behaviour of vibrating systems through an understanding of basic principles and the role of mass, stiffness and damping.
		CLO 19	Develop the equations of motion for free and forced vibration of simple systems.
		CLO 20	Explore the use of modern engineering tools, software and equipment to prepare for competitive exams, higher studies etc.

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
AME011.01	CLO 1	Understand dynamic analysis like gyroscopic forces and moments, rotation of rigid bodies.	PO 1	3
AME011.02	CLO 2	Understand the gyroscopic effect on ships, planes and road vehicles.	PO 1	3
AME011.03	CLO 3	Understand static force analysis of mechanisms.	PO 1	3
AME011.04	CLO 4	Understand dynamic force analysis of mechanisms	PO 2	2

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
AME011.05	CLO 5	Determine the dynamic behavior principle and operations of clutches, brakes, dynamometers.	PO 2	2
AME011.06	CLO 6	Compute frictional losses, torque transmission of mechanical systems such as clutches, brakes.	PO 2	2
AME011.07	CLO 7	Compute frictional losses, torque transmission of mechanical systems such as dynamometers.	PO 4	1
AME011.08	CLO 8	Understand the design of centrifugal governors.	PO 4	1
AME011.09	CLO 9	Determine the dynamic behavior principles and operations of flywheels and governors.	PO 2	2
AME011.10	CLO 10	Understand dynamic balancing of point masses.	PO 2	2
AME011.11	CLO 11	Understand dynamic balancing of rotating masses.	PO 1	3
AME011.12	CLO 12	Understand the torque calculations in turning moment diagrams.	PO 1	3
AME011.13	CLO 13	Understand dynamic balancing of reciprocating parts.	PO 1	3
AME011.14	CLO 14	Understand how to determine the natural frequencies of continuous systems starting from the general equation of displacement.	PO 1, PO 2	3
AME011.15	CLO 15	Apply the different methods to solve the equation of motion in damped forced vibrations.	PO 2	2
AME011.16	CLO 16	Understand the concepts of free and forced vibrations of single degree freedom systems.	PO 2	2
AME011.17	CLO 17	Remember the concepts of vibration modes and natural frequencies and their measurement and estimation for multi-degree-of-freedom systems.	PO 1, PO 2	3
AME011.18	CLO 18	Interpret the behaviour of vibrating systems through an understanding of basic principles and the role of mass, stiffness and damping.	PO 1, PO 2	3
AME011.19	CLO 19	Develop the equations of motion for free and forced vibration of simple systems.	PO 1, PO 2	3
AME011.20	CLO 20	Explore the use of modern engineering tools, software and equipment to prepare for competitive exams, higher studies etc.	PO 1, PO 2	3

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

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

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XII. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC 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	2											1		
CLO 2	3	2		1											
CLO 3	3												1		
CLO 4		2		1									1		
CLO 5	3	2													
CLO 6	3			1											
CLO 7		2													
CLO 8	3	2													
CLO 9		2		1											
CLO 10	3			1											
CLO 11													1		
CLO 12	3	2											1		
CLO 13	3														
CLO 14		2													
CLO 15	3														
CLO 16	3	2											1		
CLO 17				1									1		

(CLOs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 18	3	2											1		
CLO 19		2											1		
CLO 20	3	2	1										1		

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XIII. ASSESSMENT METHODOLOGIES–DIRECT

CIE Exams	PO1,PO2, PO4,PSO1	SEE Exams	PO1,PO2, PO4,PSO1	Assignments	-	Seminars	PO1,PO2, PO4,PSO1
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	PO1,PO2, PO4,PSO1						

XIV. ASSESSMENT METHODOLOGIES-INDIRECT

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

XV. SYLLABUS

Unit-I	PRECESION, STATIC AND DYNAMIC FORCE ANALYSIS OF PLANAR MECHANISMS
Precession: Gyroscopes, effect of processional motion on the stability of moving vehicles such as motor car, motor cycle, aero-planes and ships, static and dynamic force analysis of planar mechanisms: (Neglecting friction), Introduction to free body diagrams, conditions of equilibrium, two and three force members, inertia forces and D'Alembert's principle, planar rotation about a fixed centre.	
Unit-II	**CLUTCHES, BRAKES AND DYNAMOMETERS**
Clutches: Friction clutches, Single disc or plate clutch, multiple disc clutches, cone clutch and centrifugal clutch; Brakes and dynamometers: Simple block brakes, internal expanding brake, band brake of vehicle; Dynamometers absorption and transmission types, general description and method of operation.	
Unit-III	**TURNING MOMENT AND GOVERNORS**
Turning moment diagrams and flywheels: turning moment: Inertia torque, angular velocity and acceleration of connecting rod, crank effort and torque diagrams, fluctuation of energy; Design of flywheels. Governors:Watt,PorterandProellgovernors,springloadedgovernors,HartnellandHartungwithauxiliarysprings,sensitiveness, isochronism and hunting	
Unit-IV	**BALANCING OF ROTATORY AND RECIPROCATING MASSES**
Balancing: Balancing of rotating masses, single and multiple-single and different planes-balancing of reciprocating masses, primary and secondary balancing-analytical and graphical methods; unbalanced forces and couples: Balancing of V-engines, multi cylinder, inline and radial engines for primary, secondary balancing and locomotive balancing.	

Unit-V	MECHANICAL VIBRATIONS
Vibrations: Free vibration of mass attached to a vertical spring, simple problems on forced damped vibration; Vibration isolation and transmissibility, whirling of shafts, critical speeds, torsional vibrations, two and three rotor systems.	
Text Books:	
1. Thomas Bevan, "Theory of Machines", Pearson Education, 3rd Edition, 2009. 2. S.S Ratan, "Theory of Machines", Tata McGraw-Hill, 4th Edition, 2014. 3. R. L. Norton, "Kinematics and Dynamics of Machinery", McGraw-Hill, 1st Edition, 2009. 4. P.L. Balleny, "Theory of Machines and Mechanisms", Khanna publishers, 2013.	
Reference Books:	
1. J. S. Rao, R.V. Dukkipati, "Mechanism and Machine Theory", New Age Publication, 1st Edition, 2013. 2. Uiker, Penock, Shigley, "Theory of Machines and Mechanisms", Oxford University Press, 4th Edition,2013. 3. R.S. Khurmi, Gupta, "Theory of Machines", S.Chand& Co, New Delhi, 14th Edition, 2013.	

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	Introduction to Gyroscopes, angular motion, precession.	CLO 1	T2 17.2
2	Determination of Gyroscopic couple, problems.	CLO 2	T2 17.1
3	Effect of gyroscopic couple on stability of moving car.	CLO 2	T2 17.8
4	Effect of gyroscopic couple on stability of moving motorcycle.	CLO 2	T2 17.6
5	Effect of gyroscopic couple on stability of aero-plane.	CLO 1	T2 17.3
6	Effect of gyroscopic couple on stability of moving ship.	CLO 2	T2 17.4
7	Static and dynamic force analysis of planar mechanisms.	CLO1	T2 12.1
8	Free body diagrams, problems.	CLO 2	T2 12.6
9	Friction circle, Boundary friction.	CLO 2	T2 8.2
10	Introduction to Clutches, types.	CLO1	T2 8.9
11	Introduction to Brakes, classification.	CLO 1	T2 15.1
12	Introduction to dynamometers, types.	CLO1	T2 15.8
13	Methods of operation of dynamometers power, Performance test.	CLO 2	T2 15.9
14	Calculation of brake torque, problems.	CLO 2	T2 15.13
15	Turning moment diagrams explanation.	CLO 5	T2 13.12
16	Inertia torque calculation for connecting rod.	CLO 4	T2 13.11
17	Problems on inertia torque calculation for connecting rod.	CLO 5	T2 13.7
18	Fluctuation of energy.	CLO 3	T2 13.13
19	Flywheel and its function.	CLO 3	R3 16.12
20	Flywheel design	CLO 3	R3 16.18
21	Problems on flywheel	CLO3	R3 16.21
22	Introduction to governors and their classification	CLO 1	T2:16.1
23	Watt governor and Porter governor	CLO 2	T2 16.3,4
24	Proell governor, Hartnell and Hartung governors	CLO 2	T2:16.5,6
25	Problems on governors	CLO 3	T2:16.14
26	sensitiveness, isochronisms and hunting, effort and power of governors	CLO 3	R318.12
27	Balancing of rotating masses	CLO 1	T2:21.2
28	Problems on balancing of rotating masses.	CLO2	T2:21.1

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
29	Primary balancing of reciprocating masses.	CLO 2	T2:22.1
30	Secondary balancing of reciprocating masses.	CLO 2	T2:22.2
31	Higher balancing of reciprocating masses.	CLO2	R3 22.10
32	Locomotive balancing.	CLO1	R322.4
33	Graphical method of calculating forces and couples.	CLO4	R3 22.3
34	Balancing of Multi cylinder and V- Engines.	CLO2	R3 22.13
35	Balancing of radial engines.	CLO2	R3 22.12
36	Introduction to vibrations and their classification.	CLO1	T2.18.1
37	Free vibrations of mass attached to vertical springs.	CLO1	T2 18.6
38	Transverse vibrations-Problems.	CLO2	R3 23.9
39	Frequency of transverse vibration for concentrated and distributed loads	CLO2	R3 23.11
40	Dunkerley's method for calculating frequency.	CLO 14	R3 23.4
41	Raleigh's method for frequency calculations.	CLO 15	R3 23.5
42	Critical speeds, Whirling of shafts, problems.	CLO 14	R3 23.12
43	Torsional vibrations- one rotor system.	CLO 15	R3 24.4
44	Torsional vibrations- two rotor system.	CLO 16	R3 24.5
45	Torsional vibrations- three rotor system.	CLO 16	R3 24.6
46	Problems on torsional vibrations.	CLO 17	R3 24.4
47	Vibration isolation	CLO 16	R3 23.18
48	Vibration transmissibility	CLO 17	R3 23.18
49	Problems on vibration isolation and transmissibility.	CLO 16	R323.23
50	Damping ratio	CLO 17	R3 23.14

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

S NO	Description	Proposed actions	Relevance with POs	Relevance with PSOs
1	To improve standards and analyze the concepts.	Seminars	PO 1	PSO 1
2	To understand the technology of thermo-electric refrigeration, solar powered refrigeration, etc.	Seminars / NPTEL	PO 4	PSO 1
3	Encourage students to solve real time applications and prepare towards competitive examinations.	NPTEL	PO 2	PSO 1

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