INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

MECHANICALENGINEERING

COURSE DESCRIPTOR

Course Title	MECHANICAL VIBRATIONS				
Course Code	AME524				
Programme	B.Tech				
Semester	VI	ME			
Course Type	Elective				
Regulation	IARE - R16				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	-	3	-	-
Chief Coordinator	Mr. VVSH Prasad, Associate Professor.				
Course Faculty	Mr. VVSH Prasad, Associate Professor.				

I. COURSE OVERVIEW:

The course aims to teach basic concepts and recent developments related to mechanical vibrations, structural dynamics and vibration control. Vibrations in machines and structures are typically undesirable as they produce stresses, energy losses and increased bearing loads. This course covers the vibrations of discrete systems and continuous structures and introduces the computational dynamics of linear engineering systems. Gain an understanding of the concepts of natural frequencies and mode shapes and their significance.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AME011	V	Dynamics of Machinery	4
UG	AME009	IV	Kinematics of Machinery	4

III. MARKSDISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Mechanical Vibrations	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	Assignments

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 basic concepts of mechanical vibrations and phenomena of transmissibility.
II	Analyze mechanical systems with or without damping for single and multi degrees of freedom environment.
III	Application of vibration measuring instruments and machine monitoring systems.
IV	Develop competency in analytical methods in solving problems of vibrations along with mode shapes.

IX. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Understand the equations of motion of single degree of freedom systems.	CLO 1	Understand the degree of freedom of systems.
		CLO 2	Understand the simple harmonic motion of various systems.
		CLO 3	Understand the undamped and damped free vibrations.
		CLO 4	Understand the forced vibrations and columb damping.

COs	Course Outcome	CLOs	Course Learning Outcome
		CLO 5	Understand the vibration isolation and transmissibility.
		CLO 6	Compute the natural frequency of single degree of freedom systems.
		CLO 7	Understand the non periodic excitations.
CO 2	Understand the equations of motion of two degree of freedom systems.	CLO 8	Understand the two degree of freedom systems.
		CLO 14	Understand the vibration measuring instruments.
		CLO 9	Determine the mode shapes of two degree of freedom systems.
CO 3	Understand the equations of motion of multi degree of freedom systems.	CLO 10	Understand the multi degree of freedom systems.
		CLO 11	Determine the Eigen values.
		CLO 12	Determine the normal modes and their properties.
		CLO 13	Determine the free and forced vibration by Modal analysis.
CO 4	Explore the concept of frequency domain of vibration analysis	CLO 15	Understand the frequency domain vibration analysis.
		CLO 16	Understand the trending analysis of various systems.
CO 5	Explore the natural frequencies by using numerical methods	CLO 17	Understand the Raleigh‟s method of multi degree of freedom system.
		CLO 18	Understand the matrix iteration method of multi degree of freedom system.
		CLO 19	Understand the Raleigh‟s Ritz method of multi degree of freedom system.
		CLO 20	Understand the Holzerd‟s method of multi degree of freedom system.

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
AME524.01	CLO 1	Understand the degree of freedom of systems.	PO 1	3
AME524.02	CLO 2	Understand the simple harmonic motion of various systems.	PO 1	3
AME524.03	CLO 3	Understand the undamped and damped free vibrations.	PO 1	3
AME524.04	CLO 4	Understand the forced vibrations and columb damping.	PO 2	2
AME524.05	CLO 5	Understand the vibration isolation and transmissibility.	PO 2	2
AME524.06	CLO 6	Compute the natural frequency of single degree of freedom systems.	PO 2	2
AME524.07	CLO 7	Understand the non periodic excitations.	PO 4	1
AME524.08	CLO 8	Understand the two degree of freedom systems.	PO 4	1
AME524.09	CLO 9	Determine the mode shapes of two degree of freedom systems.	PO 2	2
AME524.10	CLO 10	Understand the multi degree of freedom systems.	PO 2	2
AME524.11	CLO 11	Determine the Eigen values.	PO 1	3
AME524.12	CLO 12	Determine the normal modes and their properties.	PO 1	3

AME524.13	CLO 13	Determine the free and forced vibration by Modal analysis.	PO 1	3
AME524.14	CLO 14	Understand the vibration measuring instruments.	PO 1, PO 2	3
AME524.15	CLO 15	Understand the frequency domain vibration analysis.	PO 2	2
AME524.16	CLO 16	Understand the trending analysis of various systems.	PO 2	2
AME524.17	CLO 17	Understand the Raleigh"s method of multi degree of freedom system.	PO 1, PO 2	3
AME524.18	CLO 18	Understand the matrix iteration method of multi degree of freedom system.	PO 1, PO 2	3
AME524.19	CLO 19	Understand the Raleigh"s Ritz method of multi degree of freedom system.	PO 1, PO 2	3
AME524.20	CLO 20	Understand the Holzerd"s method of multi degree of freedom system.	PO 1, PO 2	3

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

Course Outcomes (COs)	Program Outcomes			Program Specific Outcomes (PSOs)		
	PO1	PO2	PO4	PSO1	PSO2	PSO3
CO 1	2	2	3	2	1	3
CO 2	3			3	3	
CO 3	3	3	3	2	2	
CO 4	3	2		3		
CO 5					3	

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XII. MAPPING COURSE LEARNING 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												1		
CLO 2	3												1		
CLO 3	3												1		
CLO 4		2													
CLO 5		2				1									
CLO 6		2													
CLO 7				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 8				1											
CLO 9		2											1		
CLO 10		2											1		
CLO 11	3					1									
CLO 12	3														
CLO 13	3														
CLO 14	3	2											1		
CLO 15		2													
CLO 16		2													
CLO 17	3	2											1		
CLO 18	3	2											1		
CLO 19	3	2											1		
CLO 20	3	2											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	SINGLE DEGREE OF FREEDOM SYSTEMS
Single degree of freedom systems: Undamped and damped free vibrations; forced vibrations coulomb damping; Response to excitation; rotating unbalance and support excitation; vibration isolation and transmissibility, response to non Periodic Excitations: Unit impulse, unit step and unit ramp functions; response to arbitrary excitations, the convolution integral; shock spectrum; System response by the laplace transformation method.	
Unit-II	**TWO DEGREE FREEDOM SYSTEMS**
Two degree freedom systems: Principal modes, undamped and damped free and forced vibrations; undamped vibration absorbers.	

Unit-III	MULTI DEGREE FREEDOM SYSTEMS
Multi degree freedom systems: Matrix formulation, stiffness and flexibility influence coefficients; Eigen value problem; normal modes and their properties; Free and forced vibration by Modal analysis. Method of matrix inversion; Torsional vibrations of multi-rotor systems and geared systems; Discrete-Time systems; Vibration measuring instruments: Vibrometer, velocity meters and accelerometers.	
Unit-IV	**FREQUENCY DOMAIN VIBRATION ANALYSIS**
Frequency domain vibration analysis: Overview, machine train monitoring parameters, data base development, vibration data acquisition, trending analysis, failure node analysis, root cause analysis.	
Unit-V	**NUMERICAL METHODS**
Numerical methods: Raleigh,,s stodola's, Matrix iteration, Rayleigh- Ritz Method and Holzer's methods	
Text Books:	
1. Singiresu S Rao, "Mechanical Vibration", 4th Edition, 2013. 2. G. K. Grover, "Mechanical Vibration", Nemchand & Brothers, 8th Edition, 2009. 3. J.S. Rao and K. Gupta, "Introductory Course On Theory & Practice Of Mechanical Vibrations", New Age International (p) Ltd , 2nd Edition, 2012 4. Leonard Meirovitch, "Elements of vibration Analysis", Tata McGraw-Hill, 2nd Edition, 2007. 5. John S. Mitchell, "Introduction to Machinery Analysis and Monitoring", 2nd Edition, 1993.	
Reference Books:	
1. Singh V. P, "Mechanical Vibration", Dhanpat Rai & Co (p) Ltd, 3rd Edition, 2012. 2. AD Dimarogonas, SA Paipetis, "Analytical Methods In Rotor Dynamics", Applied Science Publishers London, 1983. 3. J. S. Rao, "Rotor Dynamic", New Age International (p) Ltd., 3rd Edition, 2012. 4. B.C. Nakra and K. K. Chowdary, "Mechanical Measurements", 2nd Edition, Tata McGraw-Hill, New Delhi, 2004 5. Collacott, R.A., "Mechanical Fault Diagnosis and Condition Monitoring", 1st Edition, Chapman and Hall, London, 1977.	

XVI. COURSE PLAN:

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

Lecture No	Topics to be covered	Course Outcomes	Reference
1	Introduction to Mechanical vibrations, SHM and Basic definitions.	CO 1	TT2 17.2
2	Undamped and damped free vibrations.	CO 1	TT2 17.1
3	Forced vibrations.	CO 1	TT2 17.8
4	Response to excitation; rotating unbalance and support excitation.	CO 1	TT2 17.6
5	vibration isolation and transmissibility	CO 1	TT2 17.3
6	Response to non Periodic Excitations: Unit impulse, unit step and unit ramp functions.	CO 1	TT2 17.4
7	Response to arbitrary excitations, the convolution integral,shock spectrum.	CO 1	TT2 12.1
8	System response by the laplace transformation method.	CO 1	TT2 12.6
9	Introduction to two degree freedom systems.	CO 1	TT2 8.2
10	Principal modes, undamped and damped free and forced vibrations.	CO 1	TT2 8.9
11	Problems on principal modes, undamped and damped free and forced vibrations.	CO 2	TT2 15.1
12	Problems on principal modes, undamped and damped free and forced vibrations.	CO 2	TT2 15.8
13	Vibration absorbers.	CO 2	TT2 15.9
14	Problems on principal modes, undamped and damped free and forced vibrations.	CO 2	TT2 15.13

Lecture No	Topics to be covered	Course Outcomes	Reference
15	Multi degree freedom systems: Matrix formulation.	CO 2	TT2 13.12
16	Stiffness and flexibility influence coefficients	CO 2	TT2 13.11
17	Eigen value problem	CO 2	TT2 13.7
18	Normal modes and their properties	CO 2	TT2 13.13
19	Free and forced vibration by Modal analysis	CO 2	RT3 16.12
20	Free and forced vibration by Modal analysis	CO 2	RT3 16.18
21	Method of matrix inversion	CO 3	R3 16.21
22	Torsional vibrations of multi-rotor systems and geared systems;	CO 3	T2:16.1
23	Problems on torsional vibrations of multi-rotor systems and geared systems.	CO 3	T2 16.3,4
24	Discrete- Time systems.	CO 3	T2:16.5,6
25	Vibration measuring instruments: Vibrometer, velocity meters and accelerometers.	CO 3	T2:16.14
26	Problems on torsional vibrations.	CO 3	R318.12
27	Problems on Matrix iteration method	CO 3	T2:21.2
28	Problems on torsional vibrations	CO 3	T2:21.1
29	Frequency domain vibration analysis	CO 3	T2:22.1
30	Overview, machine train monitoring parameters	CO 3	T2:22.2
31	Data base development	CO 4	R3 22.10
32	Vibration data acquisition	CO 4	R322.4
33	Trending analysis	CO 4	R3 22.3
34	Failure node analysis	CO 4	R3 22.13
35	Root cause analysis	CO 4	R3 22.12
36	Numerical methods	CO 4	T2.18.1
37	Stodola's method	CO 4	T2 18.6
38	Problems on Stodola's method	CO 4	R3 23.9
39	Problems on Stodola's method	CO 4	R3 23.11
40	Matrix iteration	CO 4	R3 23.4
41	Problems on Matrix iteration	CO 5	R3 23.5
42	Problems on Matrix iteration	CO 5	R3 23.12
43	Problems on Matrix iteration	CO 5	R3 24.4
44	Rayleigh- Ritz Method	CO 5	R3 24.5
45	Problems on Rayleigh- Ritz Method	CO 5	R3 24.6
46	Problems on Rayleigh- Ritz Method	CO 5	R3 24.4
47	Problems on Rayleigh- Ritz Method	CO 5	R3 23.18
48	Holzer's method	CO 5	R3 23.18
49	Sums on Holzer's method	CO 5	R323.23
50	Sums on Holzer's method	CO 5	R3 23.14
51	Sums on Holzer's method	CO 5	R3 23.10

XV. 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

Prepared by:

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