



# INSTITUTE OF AERONAUTICAL ENGINEERING

(Approved by AICTE, New Delhi, Accredited by NBA, New Delhi & Affiliated to JNTUH)

## MECHANICAL ENGINEERING

### COURSE DESCRIPTION

<b>Department</b>	:	<b>MECHANICAL ENGINEERING</b>			
<b>Course Code</b>	:	<b>57027</b>			
<b>Course Title</b>	:	<b>MECHANICAL VIBRATIONS</b>			
<b>Course Category</b>	:	Core			
<b>Course Structure</b>	:	Lectures	Tutorials	Practical's	Credits
		3	2	-	3
<b>Course Coordinator</b>	:	Prof. VVSH Prasad			
<b>Team of Instructors</b>	:	Prof. VVSH Prasad			

#### I. COURSE OVERVIEW:

The course aims to teach basic concepts and recent developments related to mechanical vibrations, structural dynamics and vibration control.

The Dynamics – Introduction to Mechanical Vibration course seeks to introduce students to the fundamentals of dynamics by providing an overview on mechanical vibration. Vibrations in machines and structures are typically undesirable as they produce stresses, energy losses and increased bearing loads. They contribute to structural wear and can lead to passenger discomfort in vehicles.

This course covers the vibrations of discrete systems and continuous structures and introduces the computational dynamics of linear engineering systems. Learn how to derive equations of motion and design vibration isolation systems. Gain an understanding of the concepts of natural frequencies and mode shapes and their significance. Complete system modeling tasks and formulate equations to measure and ultimately minimize vibrations.

#### II. PREREQUISITES:

Level	Credits	Periods / Week	Prerequisites
UG	3	5	Physics, Mathematics & Numerical Methods, Engineering Mechanics, Mechanics of Solids, Theory of Machines

### III. Marks Distribution:

Sessional Marks (25)	University End Exam Marks	Total Marks
<p><b>Continuous Assessment Tests (Midterm tests):</b></p> <p>There shall be 2 midterm examinations. Each midterm examination consists of one objective paper, one subjective paper and one assignment. 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 1 - 4 units of syllabus and second midterm examination shall be conducted for 5 - 8 units. 5 marks are allocated for Assignments (as specified by the concerned subject teacher) first Assignment should be submitted before the conduct of the first mid, and the second Assignment 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.</p>	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
<b>TOTAL</b>			<b>25</b>
3	II Mid Examination	1 hour and 20 min	20
4	II Assignment lot		5
<b>TOTAL</b>			<b>25</b>
MID Examination marks to be considered as average of above 2 MID's TOTAL			
5	EXTERNAL Examination	3 hours	75
<b>GRAND TOTAL</b>			<b>100</b>

## V. Course Objectives:

- I. Develop an understanding of vibration, natural frequency, and mode shape, damping and forcing and establishing ground resonance parameters for mechanical structures.
- II. Analyze vibration problems by constructing and solving the differential equations of single degree of freedom cases.
- III. Analyze vibration problems by energy methods and spectrum analysis by Laplace transformation methods, time-frequency plots.
- IV. Apply modal analysis and synthesis to two degree of freedom cases and continuous vibration systems.
- V. Apply this understanding to vibration design problems to multi dof and critical speeds of rotors.

## VI. Course Outcomes:

1. an ability to apply principles of engineering, basic science, and mathematics (including multivariate calculus and differential equations) to model, analyze, design, and realize physical systems, components or processes, and work professionally in mechanical systems areas.
2. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
3. Become proficient in the modeling and analysis of one-dof-systems - free vibrations, transient and steady-state forced vibrations, viscous and hysteric damping.
4. Become proficient in the modeling and analysis of multi-dof systems - Lagrange's equations, reduction to one-dof systems for proportionally damped systems, modal analysis, vibration absorbers, vibration transmission, Fourier transforms.
5. An ability to identify, formulate and solve engineering problems.

## VII. How Program Outcomes are assessed:

Program Outcomes		Level	Proficiency assessed by
A	An ability to apply knowledge of mathematics, science, engineering and computing using modern tools.	H	Assignments, Midterm, University examinations.
B	An ability to design and conduct experiments, as well as to synthesize, analyze and interpret data.	H	Assignments, Midterm, University examinations.
C	An ability to design a system, component, or process to meet desired needs within appropriate constraints for public Health, safety, cultural, societal and environmental considerations.	H	Assignments, Midterm, University examinations.

Program Outcomes		Level	Proficiency assessed by
D	An ability to function on multidisciplinary teams as a member and leader.	S	Assignments, Midterm, University examinations.
E	An ability to identify, analyze, formulate, and solve diverse mechanical engineering problems	H	Assignments, Midterm, University examinations.
f	An understanding of professional, ethical, legal, security, social issues and responsibilities	N	--
G	An ability to use communication skills effectively	N	--
H	The broad education necessary to understand the local and global impact of engineering solutions in a economic, environmental, and societal context.	S	Assignments, Midterm, University examinations.
I	A Recognition of the need for and an ability to engage in life-long professional development.	S	Assignments, Midterm, University examinations.
J	A knowledge of contemporary issues and Technology up-gradations.	N	--
K	An ability to use the current techniques, skills, and modern engineering tools necessary for Mechanical Engineering practice.	H	Assignments, Midterm, University examinations.
L	Ability to acquire professional competence for facing competitive examinations for successful employment in Mechanical Engineering.	S	Assignments, Midterm, University examinations.

## VIII. Syllabus:

### MECHANICAL VIBRATIONS

#### **UNIT- I: 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

#### **UNIT-II: 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-III: Vibration measuring instruments:**

Vibrometers, velocity meters & accelerometers.

#### **UNIT- IV: TWO DEGREE FREEDOM SYSTEMS:**

Principal modes- undamped and damped free and forced vibrations; undamped vibration absorbers.

#### **UNIT-V: 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.

#### **UNIT-VI: NUMERICAL METHODS:**

Raleigh's Stodola's, Matrix iteration, Rayleigh- Ritz Method and Holzer's methods.

#### **UNIT-VII: CONTINUOUS SYSTEM:**

Free vibration of strings – longitudinal oscillations of bars-traverse vibrations of beams-torsional vibrations of shafts.

#### **UNIT-VIII: CRITICAL SPEEDS OF SHAFTS:**

Critical speeds without and with damping, secondary critical speed.

**TEXT BOOKS:**

1. Elements of Vibration Analysis by Meirovitch, TMH, 2001
2. Mechanical Vibrations by G.K. Groover

**REFERENCES:**

1. Mechanical Vibrations/Groover/Nem Chand and Bros
2. Elements of Vibration Analysis by Meirovitch, TMH, 2001
3. Mechanical Vibrations/Schaum Series/ McGraw Hill
4. Mechanical Vibrations / SS Rao/ Pearson/ 2009, Ed 4,
5. Mechanical Vibrations/Debabrata Nag/Wiley
6. Vibration problems in Engineering / S.P. Timoshenko.
7. Mechanical Vibrations and sound engineering/ A.G.Ambekar/ PHI
8. Theory and Practice of Mechanical Vibrations/JS Rao & K. Gupta/New Age Intl. Publishers/Revised 2nd Edition

**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
<b>UNIT – I</b>			
1	<b>Introduction</b> to vibrations in structural dynamics	SINGLE DEGREE OF FREEDOM SYSTEMS: Introduction.	T2, R4, R8
2-3	<b>Explain</b> phenomena of damping and energy dissipation	Undamped and damped free vibrations;	T2, R4, R8
4-5	<b>Explain</b> phenomena of damping and energy dissipation	forced vibrations coulomb damping;	T2, R4, R8
6-7	<b>Formulate</b> the governing differential equation	Response to excitation; rotating unbalance and support excitation;	T2, R4, R8
8-9	<b>Analyze</b> transient and steady state vibrations	vibration isolation and transmissibility	T2, R4, R8
<b>UNIT – II</b>			

Lecture No.	Course Learning Outcomes	Topics to be covered	Reference
10	<b>Paraphrase</b> the Non Periodic Excitation	Introduction, Response to Non Periodic Excitations	R4
11	<b>Evaluate</b> unit impulse and unit ramp functions	Unit impulse, unit step and unit Ramp functions	R4
12	<b>Demonstrate</b> arbitrary excitations	Response to arbitrary excitations	R4
13-14	<b>Evaluate</b> Convolution Integral, shock spectrum	The Convolution Integral; shock spectrum;	R4
15-16	<b>Formulate</b> Laplace Transformation methods.	System response by the Laplace Transformation method.	R4
<b>UNIT – III</b>			
Lecture No.	Course Learning Outcomes	Topics to be covered	Reference
17	<b>Develop</b> relative amplitude for a 1 dof damped excited system.	Introduction: Vibration measuring instruments.	T2, R4, R8
18-20	<b>Formulate &amp; Compare</b> with respect to magnification factor, phase angle Vs frequency ratio to identify vibrometer, velorometer, accelerometer.	Vibrometers, velocity meters & accelerometers.	T2, R4, R8
<b>UNIT-IV</b>			
Lecture No.	Course Learning Outcomes	Topics to be covered	Reference
21	<b>Write</b> 2 dof system governing equation using equilibrium method/lagrange energy method	TWO DEGREE FREEDOM SYSTEMS:Introduction, Principal modes	T2, R4, R8
22-24	<b>Determine</b> principal frequencies and	undamped and damped free and	T2, R4, R8

	mode shapes	forced vibrations.	
25-28	<b>Explain</b> the principle and different types of vibration absorbers	undamped vibration absorbers	T2, R4, R8
<b>UNIT-V</b>			
Lecture No.	Course Learning Outcomes	Topics to be covered	Reference
29	<b>Formulate</b> Matrix equations for multi dof systems.	MULTI DEGREE FREEDOM SYSTEMS: Matrix formulation	T2, R4, R8
30-31	<b>Discuss</b> Maxwell reciprocal theorem-apply for Stiffness and flexibility influence coefficients	Stiffness and flexibility influence coefficients	T2, R4, R8
32-34	<b>Evaluate</b> Eigen values and their mode shapes for multi dof systems	Eigen value problem; normal modes and their properties	T2, R4, R8
35-38	<b>Analyze</b> two rotor and three rotor torsional systems-equivalent torsional system with/without gear inertia and its mode shapes.	Torsional vibrations of multi-rotor systems and geared systems; Discrete- Time systems.	T2, R4, R8
<b>UNIT – VI</b>			
Lecture No.	Course Learning Outcomes	Topics to be covered	Reference
39-40	<b>Identify</b> numerical methods applicable in vibration analysis (Dunker's Raleigh's methods) and Value of stodola's method.	NUMERICAL METHODS: Raleigh's stodola's,	T2, R4, R8
41-43	<b>Compare</b> matrix iteration method with other methods.	Matrix iteration	T2, R4, R8
44-46	<b>Examine</b> Rayleigh- Ritz Method	Rayleigh- Ritz Method	T2, R4, R8
47-49	<b>Apply</b> Rayleigh- Ritz Method	Holzer's methods.	T2, R4, R8
<b>UNIT – VII</b>			

Lecture No.	Course Learning Outcomes	Topics to be covered	Reference
50	<b>Develop</b> wave equation for continuous systems.	SYSTEM: Free vibration of strings	T2, R4, R8
51-53	<b>Derive</b> wave equation for longitudinal oscillations	Longitudinal oscillations of bars	T2, R4, R8
54-55	<b>Derive</b> wave equation for Traverse oscillations	Traverse vibrations of beams	T2, R4, R8
56-59	<b>Derive</b> wave equation for Torsional oscillations	Torsional vibrations of shafts.	T2, R4, R8

### UNIT – VIII

Lecture No.	Course Learning Outcomes	Topics to be covered	Reference
60-62	<b>Recognize</b> need for evaluating critical speeds of shafts.	CRITICAL SPEEDS OF SHAFTS: Critical speeds without and with damping,	T2, R4, R8
63-65	<b>Recognize</b> need for evaluating critical secondary speed and coriollis component of acceleration..	Secondary critical speed.	T2, R4, R8

#### X. Mapping course objectives leading to the achievement of the program outcomes:

Course Objectives	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
<b>I</b>	H	H			H				S		H	S
<b>II</b>	H	H	S	S	H				S	S	H	S
<b>III</b>	H	H	S	S	H					S	H	S
<b>IV</b>	H	H		S	H				S	S	H	S
<b>V</b>	H	H	S	S	H					S	H	S

**XI. Mapping course outcomes leading to the achievement of the program outcomes:**

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

**S = Supportive**

**H = Highly Related**

**Prepared By**  
**Date**

: Prof. V.V.S.H. PRASAD  
: 25 May, 2015

**HOD, MECHANICAL ENGINEERING**

