INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING

COURSE DESCRIPTION FORM

Course Title	**MECHANICAL VIBRATIONS AND STRUCTURAL DYNAMICS**			
Course Code	**A72122**			
Regulation	**R15-JNTUH**			
Class	**IV-B.Tech I Semester**			
Course Structure	**Lectures**	**Tutorials**	**Practical's**	**Credits**
	4	-	-	4
Course Coordinator	**Mr. GSD Madhav, Assistant Professor, Dept of AE**			
Team Instructors	**Mr. GSD Madhav, Assistant Professor, Dept of AE** **Ms. Y Shwetha, Assistant Professor, Dept of AE**			

I. COURSE OVERVIEW

Vibration is the study of oscillatory motions. It is both useful and harmful for engineering systems. The concept of vibration is profitably used in musical instruments, propagation of sound, etc. Excessive vibration causes discomfort to human beings, damage to buildings and rapid wear of machine parts such as bearings and gears. Therefore the study of vibration is important for Aeronautical engineering students and practitioners. This course discusses basic concepts of vibration with its application. The subject covers the chapters as fundamental vibration, undammed and damped single degree of freedom system, Multi degrees of freedom system, continuous systems, Transient vibrations and Non-linear vibrations.

II. PREREQUISITE(S)

Level	Credits	Periods	Prerequisites
UG	4	5	Engineering mechanics
UG	4	5	Strength of mechanics
UG	4	5	Aerospace Vehicle Structures
UG	4	5	Finite Element Method

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.	75	100

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 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

At the end of the course, the students will be able to:

I. Understand and appreciate the importance of vibrations in mechanical design of machine parts that operate in vibratory conditions.
II. Learn various linear vibratory models of dynamic systems with changing complexities (SDOF, MDOF).
III. Analyze the differential equation of motion of vibratory systems.
IV. Identify free and forced (harmonic, periodic, non-periodic) vibration analysis of single and multi degree of freedom linear systems.
V. Understand the effect of aerodynamic and elastic forces acting on aircraft wing.

VI. COURSE OUTCOMES

It is expected from the student that he/she comes out with the following knowledge at the end of this course:

1. Ability to create a FBD for a system of rigid bodies.
2. Understood the parameters and variables of a vibrating system.
3. Can represent the vibration phenomena as a mathematical model and evaluate it to obtain the response.
4. Understood the concept of natural frequency and how to find it for a vibrating system.
5. Understood the concept of Degree of Freedom in vibrating system.
6. Convert the physical model into mathematical model for various vibratory system models.
7. Learn how to analyze the free and forced vibrating system for several load conditions.
8. Develop equations for undamped and damped model for different damping systems.
9. Analyze the harmonic motion of vibratory system and to know its response.
10. Understand the response of any vibratory system by different methods
11. Determine the behavior of system under different vibratory conditions.
12. Solve the Eigen value problems for damped and undamped vibratory systems.
13. Apply the numerical methods for analyzing the string or cable problems.
14. Understand the process of vibration measurements and an introduction about continues systems.
15. Differentiate longitudinal and lateral vibrations for strings and cable.

VII. HOW PROGRAM OUTCOMES ARE ASSESSED

Program Outcomes (POs)		Level	Proficiency assessed by
PO1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	S	Assignments
PO2	**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.	H	Assignments
PO3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	H	Micro projects
PO4	**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.	S	Micro Projects
PO5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	H	Micro Projects
PO6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	--	--
PO7	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	--	--
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	--	--
PO9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	S	Micro Projects
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	--	--
PO11	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	--	----
PO12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	--	----

S - Supportive **H – Highly Related**

VIII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED

Program Specific Outcomes		Level	Proficiency Assessed by
PSO 1	**Professional Skills:** To produce engineering professional capable of synthesizing and analyzing mechanical systems including allied engineering streams.	H	Assignments,
PSO 2	**Design/Analysis:** An ability to adopt and integrate current technologies in the design and manufacturing domain to enhance the employability.	S	Assignments,
PSO 3	**Practical implementation and testing skills:** Providing different types of in house and training and industry practice to fabricate and test and develop the products with more innovative technologies	N	---
PSO 4	**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

IX. SYLLABUS

UNIT – I

FREE VIBRATION OF SINGLE-DEGREE-OF-FREEDOM-SYSTEM

Importance of the Study of Vibration; Basic Concepts of Vibration - Elementary Parts of Vibrating Systems, Number of Degrees of Freedom, Discrete and Continuous Systems; Classification of Vibration - Free and Forced Vibration, Undamped and Damped Vibration, Linear and Nonlinear Vibration, Deterministic and Random Vibration; Vibration Analysis Procedure, Spring Elements, Mass or Inertia Elements, Damping Elements, Harmonic Motion, Harmonic Analysis.

Introduction, Free Vibration of an Undamped Translational System, Free Vibration of an Undamped Torsional System, Response of First Order Systems and Time Constant, Rayleigh s Energy Method, Free Vibration with Viscous Damping, Graphical Representation of Characteristic Roots and Corresponding Solutions, Parameter Variations and Root Locus Representations, Free Vibration with Coulomb Damping, Free Vibration with Hysteretic Damping, Stability of Systems

UNIT – II

VIBRATION UNDER HARMONIC FORCING CONDITIONS

Introduction, Equation of Motion, Response of an Undamped System Under Harmonic Force, Response of a Damped System Under Harmonic Force, Response of a Damped System Under $F(t)=F0ei\omega t$, Response of a Damped System Under the Harmonic Motion of the Base, Response of a Damped System Under Rotating Unbalance, Forced Vibration with Coulomb Damping, Forced Vibration with Hysteresis Damping, Forced Motion with Other Types of Damping, Self-Excitation and Stability Analysis, Transfer-Function Approach.

UNIT – III

VIBRATION UNDER GENERAL FORCING CONDITIONS

Introduction, Response under a general periodic force, Response under a periodic force of irregular form, response under nonperodic force, convolution integral, response spectrum, Laplace transform, numerical methods, response to irregular forcing conditions using numerical methods.

UNIT – IV

TWO-DEGREE- AND MULTI-DEGREE-OF-FREEDOM SYSTEMS

Introduction, Equations of Motion for Forced Vibration, Free Vibration Analysis of an Undamped System, Torsional System, Coordinate Coupling and Principal Coordinates, Forced-Vibration Analysis, Semi-definite Systems, Self-Excitation and Stability Analysis Modeling of Continuous Systems as Multi-degree-of-Freedom Systems, Using Newtons Second Law to Derive Equations of Motion, Influence Coefficients - Stiffness Influence Coefficients, Flexibility influence Coefficients, Inertia Influence Coefficients; Potential and Kinetic Energy Expressions in Matrix Form, Generalized Coordinates and Generalized Forces, Using Lagrange s Equations to Derive Equations of Motion, Equations of Motion of Undamped Systems in Matrix Form, Eigenvalue Problem, Solution of the Eigenvalue Problem, Expansion Theorem, Unrestrained Systems, Free Vibration of Undamped Systems, Forced Vibration of Undamped Systems Using Modal Analysis, Forced Vibration of Viscously Damped Systems, Self-Excitation and Stability Analysis.

UNIT – V

CONTINUOUS SYSTEMS

Introduction, Transverse Vibration of a String or Cable, Longitudinal Vibration of a Bar or Rod, Torsional Vibration of a Shaft or Rod, Lateral Vibration of Beams, the Rayleigh-Ritz Method.

TEXT BOOKS

1. R.W. Clough and Penzien, *Dynamics of Structures.*
2. Rao, Singiresu S. *Mechanical Vibrations*, Pearson Education LPE-2004.
3. Rao, J.S and Gupta .K, *Theory and practice of Mechanical Vibrations*, Wiley Eastern Ltd., New Delhi, 2002.

REFERENCES

1. Megson, T.H.G., *Aircraft Structures for Engineering Students* Butterworth-Heinemann is an imprint of Elsevierl, Oxford OX2 8DP, UK- 2007
2. Fung, Y.C., *An Introduction to Theory of Aeroelasticity*, John Wiley & Sons, NewYork,1984
3. Timoshenko, S., *Vibration Problems in Engineering*, John Wiley and Sons, New York,1987.
4. Harris & Creed, *Shock and Vibrations*, third edition, McGraw-Hill Book Company.
5. Singh, V.P., *Mechanical Vibrations*, Dhanapati Rai and Co. 2003 edition.
6. Grahamkelly, S., *Mechanical Vibrations*, TMH 2004 edition.
7. Groover, G.K., *Mechanical Vibrations*, Nemchand and Brothers 2001 edition.
8. *Vibrations and Waves MIT series 1987*, CBS Publishers and Distributors
9. Scanlon, R.H., & Rosenbaum, R., *Introduction to the Study of Aircraft Vibration & Flutter* John Wiley and Sons, New York, 1982

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	Introducing the subject Mechanical	Introduction to Mechanical vibrations and Dynamic	T1:1.1

	vibrations and Dynamic structures.	structures	
UNIT I			
2	Explain about basic concept of Mechanical vibrations and Dynamic structures	Basic concepts, Historical back ground, Application of Mechanical vibrations and Dynamic structures	T1:1.1
3	Classification of vibration	General Description, Simple harmonic motion, terminology. Degrees of freedom	T1:1.1
4	Explain Free vibrations and forced vibrations, Damped and Undamped system	Free vibrations and forced vibrations- examples of single degree of freedom mechanical vibrations, equation of motion. Spring, inertia, damping elements. Undamped natural frequency, damped natural frequency, damping ratio	T1:1.2
5	Explain Damping Element	vibration analysis procedure, spring elements, mass or inertia elements, damping elements.	T1:1.2
7	Explain Harmonic motion, Analysis	Harmonic motion, harmonic analysis.	T1:1.2
8	Explain vibration of undamped system.	Introduction, free vibration of an undamped translational system.	T1: 2.1.1
9	Explain Undamped Tosional system	Free vibration of an Undamped Torsional system	
10	Explain First Order system And Time constant	Response of first order systems and time constant, Rayleigh's energy method, free vibration with viscous with viscous Damping.	T1: 9.2.2
11	Explain Character Roots.	Graphical Representation of Characteristic roots And Corresponding solutions	T1:9.2.3
12	Explain Root locus Representation.	parameter variations and root locus representations	T1: 2.1
13	Explain free vibration with coulomb Damping, Hysteretic Damping.	Free vibration with coulomb damping, free vibration with hysteretic damping.	T1:2.2
14	Explain Stability of systems	Stability of systems	T1:2.3-2.7
UNIT II			
15	Explain Harmonic Forcing Condition	Vibration under harmonic forcing conditions.	T1:2.8,2.9
16	Explain Equation of motion, Undamped system, Harmonic Force	Introduction, equation of motion, response of an undamped system under harmonic force.	T2:6.1
17	Explain Damped System Under Harmonic Force, under harmonic motion of the base, Under Rotating Unbalance.	Response of a Damped System under harmonic force, Response of Damped system under F(T)=FOEI, Response of Damped System under harmonic motion of Base, Response of Damped system under Rotating Unbalance.	T2:6.2
18	Explain Forced vibration with coulomb Damping, hysteresis Damping	forced vibration with coulomb damping, forced vibration with hysteresis damping.	T2:6.3
19	Explain Other types of Damping	Forced motion with other types of damping	T1:5.1
20	Explain self-excitation and stability analysis.	Forced motion with other types of damping, self-excitation and stability analysis, transfer-function approach.	T1:5.1
21	Explain Problems	Numerical problems	T1:5.1
UNIT-III			
22	Expain forced vibration	Vibration under general forcing conditions	T1:5.2

23	Explain Periodic Force	Introduction, Response under a general periodic force.	T1:5.2
24	Explain Non Periodic Force	Response under a periodic force of irregular form, response under non-periodic force	T1:5.3
25	Explain Probles	Numerical Problems	T1:6.5
26	Explain Irregular form of Periodic and Non Periodic Form	response under a periodic force of irregular form, response under non-periodic force.	T1:6.5
27	Explain Convolution Integral	convolution integral	T1:6.1.2
28	Explain RESPONSE SPECTRUM	Response spectrum	T1:6.2
29	Explain Laplace Transform	Laplace Transform	T1:6.1.2
30	Solve the problems on vibratory system	Numerical Problems on Laplace Transform	T1:6.2
31	Explain Numerical Methods	Numerical Methods	T1:6.2
32	Explain Irregular forcing conditions	Response to irregular forcing conditions using numerical methods.	T1:6.3
		UNIT- IV	
33	Explain two-degree- and multi-degree-of-freedom systems	Two-degree- and multi-degree-of-freedom systems	T1:6.1.2
34	Explain equations of motion for forced vibration	Equations of motion for forced vibration	T1:6.2
35	Explain free vibration analysis	Free vibration analysis	T1:6.2
36	Understand torsional system	Torsional system	T1:6.2.3
37	Explain principal coordinates	Coordinate coupling and principal coordinates	T1:6.3
38	Understand the concept of forced vibration	Forced-vibration analysis	T2:3.8
39	Explain definite systems	Semi-definite systems	T1:6.1.2
40	Explain self-excitation and stability	Self-excitation and stability analysis	T1:6.2
41	Explain multi degree freedom system	Modeling of continuous systems as multi-degree-of-freedom systems	T1:6.2.3
42	Deriving the equation of motion	Using newtons second law to derive equations of motion	T1:6.3
43	Discuss influence of coefficients and stiffnes	Influence coefficients - stiffness influence coefficients	T2:3.8
44	Concept of flexible influence coefficients	Flexibility influence coefficients	T1:6.5
45	Concept of inertia influence coefficients	Inertia influence coefficients	T1:6.1
46	Discuss the KE expression in matrix form	Potential and kinetic energy expressions in matrix form	T1:6.1.2
47-50	Discuss generalized coordinates and forces	Generalized coordinates and generalized forces	T1:6.2
51-52	Derive lagrange's equation for equation of motion	Using lagrange s equations to derive equations of motion	T1:6.2
53	Derive equation of motion for undamped system in matrix form	Equations of motion of undamped systems in matrix form	T1:6.2.3
54	Derivation of expansion Theorem	Expansion theorem	T1:6.1.2
55	Understand unrestrained system	Unrestrained systems	T1:6.2
56	Explain free vibration undamped system	Free vibration of undamped systems	T1:6.2

57	Concept of forced vibration undamped system	Forced vibration of undamped systems using modal analysis	T1:6.2.3
58	Concept of forced vibration damped system	Forced vibration of viscously damped systems	T1:6.3
59	Discuss self excitation and stability	Self-excitation and stability analysis	T1:6.2.3
		UNIT – V	
60	Introduction for continuous systems	Continuous systems	T1:6.1.2
61	Concept of transverse vibration	Introduction , transverse vibration of a string or cable	T1:6.2
62	Explain longitudinal vibration	Longitudinal vibration of a bar or rod	T1:6.2
63	Describe torsion vibration	Trosional vibration of a shaft or rod	T1:6.2.3
64	Disuss lateral vibration	Lateral vibration of beams	T1:6.3
65	Apply Rayleigh-Ritz method	The rayleigh-ritz method.	T2:3.8

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	H	S			S								H			
II			S		S				S						S	
III	H	S	S										H			
IV		S			S								H		S	
V					S											

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		H		S									H		S	
2	H		H										H			
3			H	H					S						H	
4		H							S							
5		H														
6	S	H											H			
7					S								H		S	
8	H	S		S					H							
9	H															
10	H				S								H			
11		H		H					H						H	

12	H	S			S								S			
13															H	
14		H		H					H							
15	S	H		H	H				S				S		H	

S = Supportive **H = Highly related**

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