INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad - 500 043

STRUCTURAL ENGINEERING
(Department of Civil Engineering)

COURSE DESCRIPTION FORM

Course Title	**STRUCTURAL DYNAMICS**			
Course Code	**BST004**			
Course Structure	**Lectures**	**Tutorials**	**Practicals**	**Credits**
	4	-	-	4
Course Coordinator	Dr. Akshay S K Naidu			
Team of Instructors	Dr. Akshay S K Naidu			

I. COURSE OVERVIEW

Structural Dynamics is of utmost importance for understanding the analysis and design consideration of structures subjected to dynamic loading. This course introduces the basic concepts of dynamic loading and the response of structures to such loads, and then uses these concepts to illustrate applications in practical structures. It begins with the derivation of the basic equations of motion for an ideal single degree-of-freedom structure using various approaches, and the solution of these equations for different types of loading, with the emphasis on the physical behaviour of the structure to different types of loads to establish simplified methods of analysis. An emphasis on earthquake response of structures is also provided. Further, the development of equations for multi-degree-of-freedom structures is considered, with multi-storied buildings as the example structures, and free and forced vibration response analysis of these multi-storied buildings shall be discussed. An introduction to the dynamics of continuous systems is provided.

II. PREREQUISITE(S)

Level	Credits	Periods	Prerequisite
UG	4	4	ENGINEERING MECHANICS
UG	4	4	STRENGTH OF MATERIALS
UG	4	4	STRUCTURAL ANALYSIS

III. MARKS DISTRIBUTION

Subject	SEE Examination	CIA Examination	Total Marks
Structural Dynamics	70 Marks	30 Marks	100 Marks

Semester End Examination (SEE) All the Units (1, 2, 3, 4 and 5)	70 Marks (3 Hours)	5 questions to be answered. Each question carries 14 Marks

<table>
<tr><td rowspan="6">Average of two CIA Examinations</td><td colspan="4">Continuous Internal Assessment - 1</td></tr>
<tr><td rowspan="3">30 Marks
(2 Hours)</td><td rowspan="3">Units
I, II and
III (half)</td><td rowspan="2">Continuous Internal Examination (CIE)
(2 hours)</td><td>Part - A
5 questions to be answered out of 5 questions, each carries 1 mark.</td></tr>
<tr><td>Part - B
4 questions to be answered out of 5 questions, each carries 5 marks.</td></tr>
<tr><td>Quiz-I /Alternate Assessment Tool (AAT- I)</td><td>5 marks for assignment.</td></tr>
<tr><td colspan="4">Continuous Internal Assessment - 2</td></tr>
<tr><td rowspan="3">30 Marks
(2 Hours)</td><td rowspan="3">Units
III (half)
IV and V</td><td rowspan="2">Continuous Internal Examination (CIE)
(2 hours)</td><td>Part – A
5 questions to be answered out of 5 questions, each carries 1 mark.</td></tr>
<tr><td>Part - B
4 questions to be answered out of 5 questions, each carries 5 marks.</td></tr>
<tr><td>Quiz-II /Alternate Assessment Tool (AAT- II)</td><td>5 marks for assignment.</td></tr>
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IV. EVALUATION SCHEME

S. No	Component	Duration	Marks
1	CIE - I Examination	2 hour	25
2	Quiz - I / AAT - I	30 minutes	05
TOTAL			30
3	CIE - II Examination	2 hour	25
4	Quiz - II / AAT - II	30 minutes	05
TOTAL			30
CIA Examination marks to be considered as average of above two CIA’s			
5	EXTERNAL Examination	3 hours	70
GRAND TOTAL			100

V. COURSE OBJECTIVES

The course should enable the students to:

I. Understand the basic principles of dynamic analysis of structures and vibratory systems
II. Formulate the dynamic equations of motions for discretized and continuous systems
III. Analyse the dynamic free and forced responses of discretized and continuous systems
IV. Analyze the response of multi-storeyed buildings for various dynamic loads including earthquake loads.

VI. COURSE OUTCOMES

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

I. Explain the basic elements of a vibratory system and terminology in dynamic analysis
II. Model the continuous systems into single and multi-degree of freedom systems using lumped mass idealization and formulate the differential equations of dynamic motion
III. Solve the differential equations of motion for SDoF and MDoF systems and analyze their solutions
IV. Analyze the free vibration response and forced vibration responses for both undamped and damped systems
V. Explain and apply the Stodola and Holzer methods for practical vibration analysis
VI. Derive and solve the governing differential equation of motion for simple continuous beams
VII. Extract and analyze the natural frequencies and mode shapes of discrete and continuous vibratory systems
VIII. Apply concepts for dynamics to carry out earthquake analysis for multi-storeyed buildings

VII. HOW PROGRAM OUTCOMES ARE ASSESSED

Program outcomes		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.	H	Examinations and 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	Examinations and 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.	-	-
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.	-	-
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.	-	-
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	-	--
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.	-	--

VIII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED

Program Specific Outcomes		Level	Proficiency Assessed by
PSO1	**Engineering Knowledge:** Graduates shall demonstrate sound knowledge in analysis, design, laboratory investigations and construction aspects of civil engineering infrastructure, along with good foundation in mathematics, basic sciences and technical communication	H	Examinations and Assignments
PSO2	**Broadness and Diversity**: Graduates will have a broad understanding of economical, environmental, societal, health and safety factors involved in infrastructural development, and shall demonstrate ability to function within multidisciplinary teams with competence in modern tool usage.	-	
PSO3	**Self-Learning and Service:** Graduates will be motivated for continuous self-learning in engineering practice and/or pursue research in advanced areas of civil engineering in order to offer engineering services to the society, ethically and responsibly	-	

N - None **S - Supportive** **H – Highly related**

IX SYLLABUS

UNIT – I

THEORY OF VIBRATIONS

Theory of vibrations: Introduction, elements of vibratory system, degrees of freedom, continuous system, lumped mass idealization, oscillatory motion, simple harmonic motion, vectorial representation of S.H.M., free vibrations of single degree of freedom system, undamped and damped vibrations, critical damping, logarithmic decrement, forced vibration of SDOF systems, harmonic excitation, dynamic magnification factor, phase angle, bandwidth

UNIT – II

SDOF SYSTEM

Introduction to Structural Dynamics: Fundamental objectives of dynamic analysis, types of prescribed loading, methods of discretization, formulation of equations of motion by different methods, direct equilibration using newton's law of motion / d'alembert's principle, principle of virtual work and hamilton principle.

Single degree of freedom systems: Formulation and solution of the equation of motion, free vibration response, response to harmonic, periodic, impulsive and general dynamic loadings, duhamel integral.

UNIT – III

MDOF SYSTEM

Multi Degree of Freedom Systems: Selection of the degrees of freedom, evaluation of structural property matrices, formulation of the MDOF equations of motion, undamped free vibrations. Solutions of Eigen value problem for natural frequencies and mode shapes, analysis of dynamic response, normal co-ordinates, uncoupled equations of motion, orthogonal properties of normal modes, mode superposition procedure.

UNIT – IV

VIBRATION ANALYSIS

Practical Vibration Analysis: Introduction, stodola method, fundamental mode analysis, analysis of second and higher modes, holzer method, basic procedure.

Continuous systems: Introduction, flexural vibrations of beams, elementary case, derivation of governing differential equation of motion, analysis of undamped free vibrations of beams in flexure, natural frequencies and mode-shapes of simple beams with different end conditions, principles of application to continuous beams.

UNIT – V

EARTHQUAKE ANALYSIS

Introduction to Earthquake Analysis: Introduction, excitation by rigid base translation, lumped mass approach - SDOF and MDOF systems - I. S. Code methods of analysis for obtaining response of multi storied buildings.

Text Books:

1. Dynamics of Structures by Clough & Penzien, McGraw Hill, New York
2. Structural Dynamics by Mario Paz, CBS Publishers, New Delhi (2004).
3. Dynamics of Structures by Anil K. Chopra, Pearson Education (Singapore), Delhi (2007).
4. IS: 1893 – 1984, "Code of practice for Earthquake resistant design of Structures" and latest IS: 1893 - 2002 (version) Part-1

Reference Books:

1. Dynamics of Structures by J. L. Humar, CRC Press (1990).
2. Wind effects on structures: fundamentals and applications to design by E. Siniu and R. H. Scanlan , John Wiley and Sons (1997).

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	Describe the elements of vibratory system	Vibratory system	T1, T2, T3
2	Understand the concept of DOF	Degrees of Freedom	T1, T2, T3
3	Describe the lumped mass idealization.	Lumped mass idealization	T1, T2, T3
4	Describe the concept of S.H.M	Simple harmonic motion	T1
5	Study the concept of free vibrations of single degree of freedom (SDOF)	Free vibrations of Single degree of freedom	T1, T2, T3
6	Describe undamped and damped vibrations for SDOF system	Undamped and damped vibrations	T1, T2, T3
7	Illustrate the concept of critical damping	Critical damping	T1, T2, T3
8	Describe logarithmic decrement	Logarithmic decrement	T1, T2, T3
9	Describe the Concept of forced vibration for SDOF	Forced vibration of SDOF.	T1, T2, T3
10	Illustrate the concept of Dynamic Magnification Factor	Dynamic magnification factor	T1, T2, T3
11	Describe the Fundamental objectives of dynamic analysis	Dynamic analysis	T1, T2, T3
12	Describe methods of discretization	Methods of discretization	T1, T2, T3
13	Illustrate the concept of direct equilibration using newton's law of motion/ d'alembert's principle	Newton's law of motion/ D'Alembert's principle	T1, T2, T3
14	Describe the principle of virtual work and Hamilton principle	Hamilton principle	T1, T2, T3
15	Illustrate the equation of motion for SDOF	Single degree of freedom	T1, T2, T3
16	Describe free vibration response for SDOF	Free vibration response	T1, T2, T3
17	Describe the concept of harmonic response to SDOF	Harmonic response to SDOF	T1, T2, T3
18	Describe structural property matrices for MDOF	Evaluation of structural property matrices	T1, T2, T3
19	Illustrate equations of motion for MDOF	System of Multi degree of freedom	T1, T2, T3
20	Describe the concept of undamped free vibrations for	Undamped free vibrations	T1, T2, T3

	MDOF		
21	Describe the Solutions of Eigen value problem for natural frequencies	Solutions of Eigen value problem for natural frequencies	T1, T2, T3
21	Describe the Solutions of Eigen value problem for mode shapes	Solutions of Eigen value problem for mode shapes	T1, T2, T3
23	Describe the analysis of dynamic response for MDOF	Analysis of dynamic response (MDOF)	T1, T2, T3
24	Describe the uncoupled equations of motion for MDOF	Uncoupled equations of motion	T1, T2, T3
25	Illustrate orthogonal properties of normal modes	orthogonal properties of normal modes	T1, T2, T3
26	Introduction to practical vibration analysis	practical vibration analysis	T1, T2, T3
27	Illustrate stodola method	Stodola method	T1, T2, T3
28	Describe the analysis of second and higher modes for vibration analysis	Analysis of second and higher modes	T1, T2, T3
29	Illustrate Holzer method	Holzer method	T1, T2, T3
30	Introduction to continuous systems	continuous systems	T1, T2, T3
31	Describe the concept of flexural vibrations of beams	flexural vibrations of beams	T1, T2, T3
32	Illustrate the analysis of undamped free vibrations of beams in flexure	undamped free vibrations of beams in flexure	T1, T2, T3
33	Describe the concept of natural frequencies of simple beams with different end conditions	natural frequencies of simple beams	T1, T2, T3
34	Describe the concept of mode-shapes of simple beams with different end conditions	mode-shapes of simple beams	T1, T2, T3
35	Describe the principles of application to continuous beams.	principles of application to continuous beams.	T1, T2, T3
36	Introduction to Earthquake analysis	Earthquake analysis	T1, T2, T3
37	Illustrate the concept of rigid base translation	rigid base translation	T1, T2, T3
38	Describe lumped mass approach for SDOF	lumped mass approach for SDOF	T1, T2, T3
39	Describe lumped mass approach for MDOF	lumped mass approach for MDOF	T1, T2, T3
40	Describe I.S. code methods of analysis for obtaining response of multi stored buildings	response of multi stored buildings	T1, T2, T3

IX. MAPPING COURSE OBJECTIVES LEADING TO THE ACHIEVEMENT OF THE PROGRAM OUTCOMES

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

S = Supportive **H = Highly related**

X. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF TSHE PROGRAM OUTCOMES

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

S = Supportive **H = Highly related**

Prepared by: Dr. Akshay S. K. Naidu, Professor

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