ACADEMIC – GRADUATE STUDIES AND RESEARCH DIVISION
FIRST SEMESTER 2022-2023
Course Handout Part II

Date: 29/08/2022

In addition to part I (General Handout for all courses appended to the time table) this portion gives further specific details regarding the course.

Course No.	**: CE G551**
Course Title	**: Dynamics of Structures**
Instructor-in-charge	**: Dr. Mohan S C**

Course Description : Free and forced Vibration Analysis of SDOF system, Response to general dynamic loadings, Numerical evaluation of dynamic response, Effect of damping; Free and forced vibration of undamped and damped multi degree of freedom systems; Model- ing for multi degree of freedom systems; Equation of motions, Evaluation of natural frequencies and mode shapes, orthogonality conditions, Modal analysis and modal combination rules, Numerical evaluation of dynamic response for multi degree of freedom, time history analysis; support excited vibration, analysis of non-linear systems, Free and forced vibration analysis of continuous systems, Random vibrations, Stochastic response; Vibration isolation, vibration absorber and tuned mass damper; Evaluation of wind, blast, wave loading and other dynamic forces on structure; Modeling and dynamic analysis of buildings, bridges, water tank, liquid storage tanks, stack like structure, machine foundations etc.

Scope and Objective of the Course:

Scope: Natural phenomena and manmade events usually impose forces of time-dependent variability on various civil engineering structures and considerations of these are essential to design a structure resistant to dynamic forces. Hence, this course is focused on analysis of structures, subjected to dynamic loads such as earthquake, wind excitations.

Learning Objectives: After the successful completion of this course, the students should be able to:

1. Formulate equation of motion of Single and Multi-Degree of Freedom systems under free and forced vibrations.

2. Evaluating the response of Single and Multi-Degree of Freedom systems under free and forced vibration with and without damping.

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3. Evaluating the response of Multi-Degree of Freedom systems using approximate and numerical methods

4. Analyze the structures subjected to dynamic loading using finite element method

5. Evaluate the lateral forces of a multi-storied building subjected to wind load.

6. Perform dynamic analysis of structures in Frequency domain

Student Learning Outcomes (SLOs) assessed in this course – **(a), (b), (e), (i), (j),** and **(k)**.

Text Book:

1. Chopra, Anil K. "Dynamics of Structures: Theory and applications to earthquake engineering", Pearson Edu., 5th edition, 2017.

Reference Books:

1. R.W. Clough and J. Penzien, "Dynamics of Structures", Third edition, McGraw Hill International edition, 2003.

2. M. Mukhopadhyay, "Structural Dynamics: Vibrations & Systems" Ane's Student Edition,2010.

3. Patrick Paultre. "Dynamics of Structures" Wiley, Reprint 2013.

4. Mario Paz, Y H Kim "Structural Dynamics - Theory and Computation", 6th Edition 2019.

5. L. Meirovitch, "Elements of Vibration Analysis", 2nd Ed., McGraw-Hill, 1986.

6. Daniel J. Inman, "Engineering Vibration", Prentice Hall of India Ltd., 2001.

7. Singiresu S. Rao, "Mechanical Vibrations" Pearson Education.2010.

8. N.C. Nigam, "Introduction to Random Vibration", MIT Cambridge, 1983.

9. E. Siniu and R.H. Scanlan, "Wind effects on structures: fundamentals and applications to design", John wiley and sons, 1997.

10. L. Fryba, "Dynamics of Railway Bridges", Thomas Telford, 1996.

11. P.Agarwal, and M. Shrikhande, "Earthquake resistant design of structures", Prentice-Hall India.2006.

1. IS 875 (Part-III):2015-Design Loads (Other than Earthquake) for Buildings and Structures — Code of Practice Part 3 Wind Loads

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Course Plan

Lec No.	Learning Objective	Topics to be covered	TB/ RB	SLO*
Introduction to Dynamics of Structures				
1	Study the fundamental concept of dynamics and develop an equation of motion for simple structures	Introduction and Scope of dynamic analysis of structures; origins of vibration theory and experiment; review of earlier concepts: D'Alembert's principle, equations of motion.	Ch.1 TB	**(a)**
2-3		Elements of a structural system: springs, mass; Springs in parallel and series; methods to formulate equations of motion: Newton's equation of motion, natural frequency.		**(a)**
Single Degree of Freedom (SDOF) System (Discrete Mass Systems)				
4-5	Evaluate the displacement, velocity and acceleration response of SDOF system with and without damping under free and various forced vibrations	Free Vibration of Undamped (conservative) systems), Damping & their types, Damping ratio, Damped (non-conservative systems) free vibration, Logarithmic Decay of Motion	Ch.2 TB	**(a), (e)**
6-8		Forced vibration of conservative and non-conservative (dissipative or damped) systems under harmonic & periodic loading, Dynamic Response factor, Resonance	Ch.3 TB	**(a), (e)**
9-11		Forced vibration of conservative and dissipative systems under arbitrary dynamic loading like impulse, step, ramp, etc. Response of SDOF system under support excitation	Ch.4 TB	**(a), (b), (e)**
Multi Degree of Freedom (MDOF) Systems (Discrete Mass Systems)				
12-15	Formulate an equation of motion and evaluate displacement, velocity and acceleration response of MDOF system (with and without damping) under free and forced vibrations	Equation of motion for MDOF, Natural frequencies, Modeshapes, Damping matrix, Rayleigh damping, non-proportional damping	Ch.9-11 TB	**(a), (e)**
16-18		Modal analysis of MDOF systems, orthogonality conditions, Free and forced vibration response of MDOF with and without damping	Ch.12 TB	**(a), (e)**
19-22		Response history analysis under support excited vibration, Response spectrum analysis, modal combination rules using absolute sum, SRSS and CQC method.	Ch.13 TB	**(a), (b), (e)**

23-26	Evaluate approximately the dynamic properties and response of MDOF system using approximate methods and numerical methods	Approximate methods for obtaining natural frequencies and mode shapes; Reyleigh-Ritz method; Time history analysis; Central Difference method, Newmark beta (average and linear acceleration) method.	Ch.14 -15 TB	**(a), (e)**

Free Vibration of Continuous Mass Systems

27-29	Derive and solve the equation of motion for a continuous mass system subjected to free vibration	Equations of motion for continuous system; natural frequency and mode shapes of continuous system. undamped free vibration response of continuous system.	Ch.16 TB	**(a), (e)**

Finite Element Modeling and Dynamic Analysis

30-32	Dynamic analysis of structures using Finite Element Method (FEM)	Modelling and Dynamic analysis of beam, plane frame, and multi-story building. Formulation of stiffness and mass matrices.	Ch.17 TB, RB2	**(a), (b), (e), (i), (j), (k)**
33-35	Analyze some of the vibration absorption / control techniques	Base isolation, tuned mass dampers etc.	Ch.20 TB,	**(a), (e)**

Wind loads on structure

36-40	Evaluating the wind loads on multi-story building using IS 875 (Part 3)	Introduction, static and dynamic wind pressure, effect of terrain.	Notes / RB-3	**(a), (e), (i). (j), (k)**

Frequency Domain Analysis of Structures

41-42	Dynamic analysis of structures in Frequency domain	Equation of motion in Frequency domain, Response of Multi-degree systems in frequency domain, Applications.	Notes / RB-3	**(a), (e)**

*Student Learning Outcomes
SLOs are outcomes (a) through (k) plus any additional outcomes that may be articulated by the program.
    (a) an ability to apply knowledge of mathematics, science and engineering
    (b) an ability to design and conduct experiments, as well as to analyze and interpret data
    (c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

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(d) an ability to function on multidisciplinary teams

(e) an ability to identify, formulate, and solve engineering problems

(f) an understanding of professional and ethical responsibility

(g) an ability to communicate effectively

(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

(i) a recognition of the need for, and an ability to engage in life-long learning

(j) a knowledge of contemporary issues

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Evaluation Scheme:

Component	Weightage (%)	Duration	Evaluation Date & Time	Nature of Component
Mid Semester Test	25	90 min	31/10 3.30 - 5.00PM	CB
Assignments (3 No.)	15	1 week each	Continuous	OB
Lab (10 No.)	15	2 hour per week	Continuous	OB
Project (1 No.)	10	2 months	Nov 2022	OB
Comprehensive Exam	35	180 min	19/12 AN	CB

Chamber Consultation Hour: Th, 4-5PM.

Notices: Notice concerning to the course will be displayed in Google classroom

Make-up Policy: Make-up will be granted only to genuine cases with prior permission from the IC. Make ups will not be given to students who contact the IC after the evaluation component.

Academic Honesty and Integrity Policy: Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

INSTRUCTOR-IN-CHARGE