Indian Institute of Technology Mandi
Proposal for a New Course

Course Number : CE 511
Course Name : Structural Dynamics with Application to Earthquake Engineering
Credits : 3-0-0-3
Prerequisites : Strength of Materials and Structures (CE301) or Equivalent
Intended for : UG (3^{rd} year and 4^{th} year), PG
Distribution : Discipline Elective (UG); Core/Elective (PG)
Semester : Odd/Even

1. **Preamble:** As most of the civil engineering structures are subjected to natural or man-made time varying loading, it is important to have appreciation of dynamic behavior of such structures. To design a simple structure such as a concrete beam, a steel girder or a complex multi-story building or a more complex nuclear power plant against such time dependent loading, it is necessary to first analyze their dynamic responses. With increasing need of earthquake resistant design for better seismic safety, understanding of the dynamic behavior of structures is becoming inevitable for the structural designers. This course is aimed to develop an understanding of the dynamic characteristics and response of structural systems. The participants are expected to be able to apply the theories of structural dynamics for analyzing typical structures under earthquake loading.

2. **Course Modules with Quantitative Lecture Hours:**

Module 1: **(3 lecture hours)**
Introduction: Overview and importance of structural dynamics; Various types of dynamic loading; Mass excited and base excited systems; Degrees of freedom (DOF); Typical force-displacement behavior of structural-elements/-systems.

Module 2: **(13 lecture hours)**
Single Degree of Freedom (SDOF) Systems: Dynamic equilibrium equation for SDOF system; Analysis for undamped free vibration; Damping in structural system; Equation of motion and analysis for damped SDOF system; Critically-damped, over-damped and under-damped systems; Estimation of damping by logarithmic decrement method; Classical and non-classical damping; Equivalent viscous damping; Response of undamped and damped SDOF system to harmonic excitation, Half-power bandwidth method for damping evaluation; Response to support motion and force transmission to foundation; Response of SDOF system to periodic, impulsive, and general dynamic loading; Duhamel's integral.

Module 3: **(10 lecture hours)**
Multi Degrees of Freedom (MDOF) Systems: Idealization of multi-story shear building as MDOF system; Equations of motion for two-story shear building; Natural frequencies of vibration, modes and mode shapes of MDOF system; Orthogonality of modes; Normalization of modes; Classically damped system; Static condensation of DOF for a multi-story building; Dynamic analysis of linear two-DOF system; Dynamic response control of structures, tuned-mass damper.

Module 4: **(4 lecture hours)**

Systems with Distributed Properties: Vibration of uniform beam with various support conditions; Free vibration analyses; Natural frequencies of vibration and modes; Dynamic response to applied force and support excitation.

Module 5: **(12 lecture hours)**

Application to Earthquake Engineering: Equation of motion with earthquake excitation; Response quantities of interest and response histories; Response spectrum concept; Characteristics of acceleration, velocity and displacement response spectra; Elastic design spectra; Modal analysis of MDOF systems; Modal superposition method and mode combination rules; Response spectrum analysis of multi-story building; Introduction to response history analysis; Indian Standard code provisions for computation of and analysis for earthquake loading; Introduction to seismic control of structures; Dynamics of base-isolated structures.

3. Textbooks:

(i) A.K. Chopra (2017), "Dynamics of Structures - Theory and Application to Earthquake Engineering", 5th Edition, Pearson, New Jersey, USA.

(ii) J.L. Humar (2012), "Dynamics of Structures", 3rd Edition, CRC Press, Taylor and Francis, New York, USA.

4. Reference Books:

(i) E.L. Wilson (2002), "Three-Dimensional Static and Dynamic Analysis of Structures", 3rd Edition, Computers and Structures, Inc., Berkeley, California, USA.

(ii) M. Paz, Leigh W. (2006), "Structural Dynamics - Theory and Computation", 5th Edition, Springer Science+Business Media LLC, New York, USA.

(iii)R.W. Clough, J. Penzien (1995), "Dynamics of Structures", 3rd Edition, Computers and Structures, Inc. Berkeley, USA.

(iv)T.K. Datta (2010), "Seismic Analysis of Structures", 1st Edition, John Wiley & Sons (Asia) Pte Ltd, Singapore.

(v) IS 1893 (Part 1) (2016), "Criteria for Earthquake Resistant Design of Structures: Part 1 General Provisions and Buildings", Bureau of Indian Standard, New Delhi, India.

5. Similarity content declaration with existing courses:

Sl. No.	Course Code	Similarity Content	Approximate % of Content
1	ME602	Mathematical foundation of vibration analysis for SDOF/MDOF systems and systems with distributed properties	25

6. Justification for new course proposal if cumulative similarity content is > 30%:

Not Applicable

Approvals:

Other faculty interested in teaching this course: Dr. Maheshreddy Gade, Dr. Rajnish Sharma

Proposed by: Dr. Sandip Kumar Saha

School: School of Engineering (SE)

Signature:

Date:

Recommended / Not Recommended, with comments:

Chairman, CPC

Date: _____

Approved / Not Approved:

Chairman, Senate

Date: _____