ROSE School | Earthquake Engineering

Dynamic Analysis of Structures

Lecturer: **G.J. O'Reilly**
Date: 13/04/2026 – 24/04/2026
Credits: 3 ECTS (CFU)

Course Description

This course provides a fundamental introduction to structural dynamics, forming the basis for later topics in earthquake engineering. It focuses on the behaviour of structures subjected to time-dependent loads and on methods used to predict their dynamic response. The course begins with the equation of motion for single-degree-of-freedom (SDOF) systems, examining free and forced vibrations, viscous damping, and resonance. The response to harmonic and general excitation is explored, together with the use of numerical techniques for time-domain analysis. The formulation of multi-degree-of-freedom (MDOF) systems is then introduced, including static condensation and the determination of natural frequencies and mode shapes. The concepts of orthogonality, normalisation, and modal expansion are developed to enable efficient analysis of complex systems. Students learn how to perform modal response analysis for forced vibration and seismic excitation, and to interpret modal contributions and element forces. The course also covers response spectrum methods, equivalent SDOF approximations, and introduces frequency domain analysis using the Discrete and Fast Fourier Transforms (DFT and FFT). By the end of the course, students will understand the key principles governing structural vibration and be able to apply analytical and computational methods to predict dynamic response under various loading conditions.

Topics

- Equation of motion for SDOF systems.
- Free vibration response, viscous damping.
- Response to harmonic and general excitation.
- Generalised SDOF systems.
- Numerical evaluation of dynamic response.
- Equations of motion for MDOF systems.
- Static condensation.
- Natural frequencies and modes.
- Orthogonality and normalisation of modes.
- Modal expansion of displacements.
- Solution for undamped free vibration.
- Damping in structures.

- Solution for damped free vibration.
- Modal response analysis: forced vibration and seismic excitation.
- Modal response analysis: element forces and modal contributions.
- Response spectrum analysis.
- Equivalent SDOF analysis.
- Frequency domain analysis: Discrete and Fast Fourier transforms.

Learning Outcomes

On completion of this course, students will be able to:

- Derive and solve equations of motion for SDOF and MDOF systems.
- Analyse free and forced vibration responses, including damping effects.
- Apply modal and response spectrum analysis to seismic loading.
- Use time and frequency domain methods for dynamic response evaluation.