UCLouvain

lgciv2042

2024

Dynamics of structures

5.00 credits	30.0 h + 15.0 h	Q1

Teacher(s)	Saraiva Esteves Pacheco De Alm João ;
Language :	English > French-friendly
Place of the course	Louvain-la-Neuve
Prerequisites	Background on strength of materials, structural mechanics and structural analysis (e.g. courses LGCIV1031, LGCIV1022 and LGCIV1023).
Main themes	See ‘Content’
Learning outcomes	**At the end of this learning unit, the student is able to :** 1 **Contribution of the course to the program objectives:** AA 1.1, AA 1.2, et AA 1.3 **At the end of this learning unit, the student is able to:** - Formulate equations of motion according to different methods (direct formulation, virtual work, variational approach) for single-degree-of-freedom (SDoF) and multi-degree of freedom (MDoF) systems, damped and undamped, linear and nonlinear. - Characterize the dynamic properties of SDoF and MDoF systems, and apply alternative solution approaches to compute their response under various loadings (both for linear and nonlinear SDoF and MDoF systems, damped and undamped). - Implement numerical time-domain integration methods and frequency domain analysis, and recognize corresponding limitations and advantages. - Understand the main principles and application of operational and experimental modal analysis. - Model and solve practical problems of structures affected by vibrations (induced by machines, earthquakes, people, wind, traffic and construction activities).
Evaluation methods	I. Assignment (30%); II. Project (40%), III. Written or oral evaluation during the quarter (30%). The assignment and project, which constitute the continuous evaluation grade, are done in groups of 2/3 students and cannot be repeated in the second session; the continuous evaluation grade acquired in the first session is retained in the event of a second session. The written or oral evaluation is individual. The oral evaluation can address the assignment and/or the project, in which case it will also be considered part of the continuous evaluation. Failure to comply with the methodological guidelines set out on Moodle, particularly with regard to the use of online resources or collaboration between students for the assignment/project, will result in an overall mark of 0 for the continuous evaluation. The use of generative artificial intelligence (such as ChatGPT, Consensus, Perplexity, Bard...) is forbidden for this course.
Teaching methods	Lectures based on course slides; exercise sessions; practical applications with a small shake table / instrumented real structure.
Content	- Linear singledegreeoffreedom (SDoF) systems: free vibration, damping values in structures, harmonic loading, evaluation of viscous damping and frequency, response to unit impulse and other forces, closed-form solution, time-domain analysis and convolution integral, force transmission, response to ground motion, vibration isolation. - Nonlinear SDoF systems: numerical time-domain integration (central difference, constant average acceleration and linear acceleration, Newmark), classification, stability, computational error, algorithmic damping, inelastic response (bilinear system). - Formulation of equations of motion: direct formulation using D’Alembert’s principle, principle of virtual work, variational approach. - Linear multidegreeoffreedom (MDoF) systems: free vibration of undamped systems (natural vibration frequencies and modes, modal and spectral matrices, orthogonality of mode shapes, normalisation, modal expansion), free vibration of damped systems, damping and energy dissipation in linear (and nonlinear) analyses, damping models, modal analysis, displacement response and element forces, restated form, modal contribution factors, modal responses and required number of modes, influence of dynamic response factor, applications (including ground motion). - Nonlinear multidegreeoffreedom (MDoF) systems: numerical time-domain integration, applications.

	- Frequency-domain method of response analysis: complex frequency response function, Fourier transform, response to arbitrary excitation, response to periodic excitation, sampling theory and discrete Fourier transform, aliasing, leakage, windows, fast Fourier transform, power spectrum density, extension to MDoF systems. - Introduction and overview of operational modal analysis and experimental modal analysis.
Inline resources	Available in Moodle.
Bibliography	- Course slides / notes. - Dynamics of structures: Theory and Applications to Earthquake Engineering, Anil K. Chopra, Prentice Hall, 2012. - Dynamics of structures, Ray W. Clough and Joseph Penzien, Computers & Structures, 2003. - Vibration problems in structures: Practical guidelines, Hugo Bachmann et al., Birkhauser Verlag, 1995.
Other infos	The course involves: - The use / development of Python / Matlab scripts; - The operation of a small shake table with model structures.
Faculty or entity in charge	GC

Programmes containing this learning unit (UE)

Program title	Acronym	Credits	Prerequisite	Learning outcomes
Master [120] in Civil Engineering	GCE2M	5		🔍
Master [120] in Mechanical Engineering	MECA2M	5		🔍
Master [120] in Electro-mechanical Engineering	ELME2M	5		🔍