lgciv2041 — Numerical analysis of civil engineering structures

2024

4.00 credits	20.0 h + 15.0 h	Q2

Teacher(s)	Rattez Hadrien ;Saraiva Esteves Pacheco De Alm João ;
Language :	English > French-friendly
Place of the course	Louvain-la-Neuve
Prerequisites	Good knowledge of Strength of Materials, Structural Analysis, and basis of the Finite Element Method, as taught in the courses LGCIV1022 and LGCIV1023.
Main themes	• Review of the Finite Element Method • Finite Element Method for Linear Elastic Shells and Solids • Consistent derivation of 3D beam theory from Continuum Mechanics • Solution methods in nonlinear problems • Geometric nonlinearities • Material nonlinearities
Learning outcomes	**At the end of this learning unit, the student is able to :** 1 **Contribution of the course to the program objectives (N°)** AA1.1, AA1.2, AA1.3, AA2.1, AA2.2, AA2.3, AA2.4, AA3.1, AA3.2, AA4.2, AA4.4, AA5.6. **Specific learning outcomes of the course** At the end of this learning unit, the student is able to: • Understand the principles and application of the finite element method as relevant to the analysis of civil engineering structures (namely beams, plates, and solid finite elements). • Develop and code several finite elements in Python, explore their features and issues, and get acquainted with a general-purpose finite-element software. This includes the treatment of input data and the post-treatment of the results. • Understand alternative approaches to modelling geometric and material nonlinear effects, and corresponding finite element implementation. • Understand advantages and limitations of different solution methods for nonlinear problems, and corresponding finite element implementation.
Evaluation methods	Continuous assessment and final oral exam. The continuous assessment is based on two written exams of 15 minutes each during the semester and an assignment. The assignment is done in groups of 2/3 students and cannot be repeated in a second session; the continuous assessment mark acquired in the first session is retained in the event of a second session. Failure to comply with the methodological guidelines, 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, etc.) is prohibited for this course.
Teaching methods	Lectures based on course slides; exercise sessions; practical applications.
Content	• Review of the Finite Element Method: Weak form, Galerkin method, Shape functions, Quadrature, Stiffness matrix, Local-global numbering, Boundary conditions, System of equations. Mesh refinement. Application to linear elastic beams. • Finite Element Method for Linear Elastic Shells and Solids: Equations of classical continuum mechanics, Variational form, Elements, Interpolation, Possible issues (rigid body motion, shear locking, volumetric locking, hourglass), Reduced integration, Thin-section solids (plates and shells). • Consistent derivation of 3D beam theory from Continuum Mechanics: Timoshenko, Extended Timoshenko with distortion and warping, Euler-Bernoulli. • Solution methods in nonlinear problems: Nonlinear response, Incremental load application, Newton-Raphson methods, Convergence criteria, Alternative iterative methods, Incremental-iterative procedures with variable loading parameter (load-control, displacement-control, work-control, arclength), Automatic load incrementation.

	• Geometric nonlinearities: Total Lagrangian, Updated Lagragian, Co-rotational formulations (total compatibility, incremental compatibility, total equilibrium, incremental constitutive relations). • Material nonlinearities: Elasticity vs plasticity, Elastoplasticity, Plasticity, Yield Criterion, Plastic flow (associated and non-associated flow rule), Strain hardening, Return mapping.
Inline resources	Available in Moodle.
Bibliography	Notes et supports de cours.
Other infos	The course involves: - The use / development of Python scripts; - The use of a commercial/research finite element software (Abaqus).
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	4		🔍
Master [120] in Mechanical Engineering	MECA2M	4		🔍
Master [120] in Electro-mechanical Engineering	ELME2M	4		🔍
Master [120] in Mathematical Engineering	MAP2M	4		🔍
Master [120] in Energy Engineering	NRGY2M	4		🔍