POLITECNICO
MILANO 1863

PhD Course: ADVFEM - ADVANCED TOPICS IN THE FINITE ELEMENT METHOD FOR STRUCTURAL ANALYSIS

The online course, open to all the interested PhD students, will be delivered in-person and via streaming in the period **21 November – 30 November 2023**.
Interested non Polimi PhD students should register to the course sending an email request to aldo.ghisi@polimi.it by **November 17, 2023**. Polimi students must register to the course through the Polimi Online Services.

Contents:
Well posedness and stability in linear elasticity finite element models (prof. M.Cremonesi)
Recap of finite elements basics.
Introduction to the problem of locking. Incompressible elasticity and volumetric locking. Shear locking.
Mixed formulations (HU-Washizu principle and alternative multi-filed forms).
Reduced and selective integration techniques and equivalence with mixed methods.
Spurious modes (hourglass).

Nonlinear finite element modelling (prof. G. Novati)
An introduction to non-linear FE analyses; iterative (Newton-Raphson) and incremental/iterative techniques.
Example problems with geometrical nonlinearity (but small strains): cables and cable-nets.
Example problems with material nonlinearity: nonlinear elastic bars.
FE elastoplastic analysis; plasticity models in 1D and 3D (von Mises, isotropic hardening); tangent elastoplastic operators; finite-step problem and return mapping algorithm; incremental finite element procedure; examples.

Contact modeling (prof. A. Ghisi)
Contact problems in continuum mechanics. Normal contact between elastic solids (Hertzian theory). Non-Hertzian contact between elastic solids. Normal contact between inelastic solids. Tangential loading and inelastic contact. Dynamic effects and impact. Energy balance.
Formulation of contact equations for finite elements. Contact interface equations. Friction models. Weak forms: Lagrangian, penalty and augmented Lagrangian formulation for implicit time integration. Penalty formulation in explicit time integration.
Common difficulties in contact problems. Poorly defined surfaces, adjust initial body position, contact noise, overconstraint.

Finite element modelling of large deformation problems (prof. S. Mariani)
Nonlinear continuum mechanics: analysis of motion and deformation gradient; Green-Lagrange and rate of deformation tensors; pull-back and push-forward operations; measures of stress through Cauchy, nominal, first and second Piola-Kirchhoff tensors; conservation laws.
Updated and Total Lagrangian approaches governing equations, strong/weak forms. Total Lagrangian approach: finite element formulation. Implicit time integration procedures.

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Explicit dynamics finite element analyses (prof. U. Perego)
Explicit dynamics approach to the finite element solution of nonlinear problems. Explicit vs. implicit time integration.
Unconditional vs. conditional stability and time step size. CFL condition.
The central difference method. Accuracy of the central difference method.
Mesh size and mesh smoothing techniques.
Mass lumping. Mass scaling vs. selective mass scaling in explicit dynamics.

Notes
Official Polimi certificates of attendance, credit acquisition, and exam taking require the online registration to the course through the Polimi PhD School (Polimi PhD students will receive a fee waiver for this specific course. Regional taxes will be due). Credit acquisition through an exam can be obtained only for Polimi PhD School students.

SCHEDULE

Teacher	Date		Time		Tot hours
Cremonesi	Tuesday	21-Nov-23	10:00-13:00	14:00-17:00	6
Novati	Wednesday	22-Nov-23	09:00-12:00	15:00-17:00	11
Perego	Friday	24-Nov-23	10:30 -12:30	14:30-16:30	15
Mariani	Monday	27-Nov-23	09:15-12:15		18
Mariani	Wednesday	29-Nov-23	09:15-11:15		20
Ghisi	Wednesday	29-Nov-23		14:15-16:15	22
Ghisi	Thursday	30-Nov-23	09:15-13:15		26

The material of the course will be made available in a password protected shared folder.
Lectures will be delivered in a virtual class. The link will be made available to registered PhD students.