

**Course offered for the PhD program  
in Civil, Chemical and Environmental Engineering  
Curriculum in Structural and Geotechnical Engineering, Mechanics and Materials  
a.a. 2022/2023**

(course is open for participation of students from other PhD cycles or programs)

**1. Title**

Nonlinear Finite Element Method for Structural Applications

**2. Course Description**

- Introduction to the Finite Element method
  - Finite element modelling
  - The direct stiffness method (bar element)
  - Variational formulation (bar element)
  - The plane stress problem: plane stress isoparametric elements
  - Shape functions, convergence requirements, numerical discretization
- Nonlinear analyses:
  - Nonlinear response diagrams: critical points
  - Residual force equations (one parameter)
  - Formulation of the bar element in large displacements
  - Overview of solution methods: predictors, predictor-correctors
  - Linearized Pre-buckling. Geometric nonlinearities. Material nonlinearities
- Applications using ANSYS: cantilever linear elastic bar subjected to non-uniform axial loading (convergence issues); linear elastic plate with circular hole (2D problem; solid modelling, meshing, convergence issues); Linearized Pre-Buckling of a portal frame (nonlinear analysis, bifurcation point); Prandtl problem (rigid foundation over an elasto-plastic soil (nonlinear analysis; limit point); Instability of an elasto-plastic beam (nonlinear analysis; geometric and material nonlinearities); Griffith problem: energy release rate and stress intensity factors in a plate with a crack (fracture mechanics)

**3. Course Organization**

Frontal lessons and practical classes in the lab.

**4. Teacher**

Prof. Roberta Massabò

**5. Duration and credits**

Around 25h, 4 CFU

**6. Activation mode and teaching period**

Period: March - June 2023. Frontal Lessons and practical classes with the course "Nonlinear Analysis of Structures" for LM students.

**7. Deadline for registration**

End of January 2023. Application: email message to the teacher  
([roberta.massabo@unige.it](mailto:roberta.massabo@unige.it))

**8. Final exam**

Application of Finite Element code ANSYS to solve a nonlinear problem of interest for your research.