Graduate course

NONLINEAR MATERIAL MECHANICS

September 6th – 8th 2021
September 13th – 15th 2021

Hosted by:
Faculty of Engineering Technology
University of Twente

TU Delft
Technische Universiteit Delft

UNIVERSITY OF TWENTE.

General

This course is an initiative of the Dutch graduate school Engineering Mechanics. The course is part of the 3TU Engineering Mechanics training programme for PhD students. As part of this programme a series of graduate courses is organized, related to the following research themes:

- Computational and Experimental Mechanics of Materials
- Structural Dynamics and Control
- Reliability and Optimization
- Linear and Nonlinear Material Theory

Objective

Reliable simulation tools in engineering and design require accurate material models. Nonlinear material behaviour plays an essential role in many applications of engineering mechanics. The engineering response of materials essentially results from the physics and mechanics of their underlying microstructure. The distinction between materials science and mechanics is becoming more and more diffuse. Multi-phase structures, voids, grains, interfaces and the presence of additional phases play an intrinsic role. Using proper knowledge from mechanics and advanced computational tools one can reach an improved understanding of the mechanical behaviour and properties of commonly applied and new materials.

This course focuses on a presentation of the fundamental aspects of the modelling of nonlinear material behaviour. It includes large deformations and solution techniques. Applications include e.g. metals and multi-phase brittle and granular materials.

Attention will be given to kinematics, stress and balance laws, thermodynamics, hyperelasticity, plasticity, anisotropy, multi-phase materials, phase transitions and damage. On the numerical side, nonlinear solution techniques, higher order continua, and discontinuous models will be introduced. In addition to continuum theory and methodology, also particle methods and the micro-macro transition from particle methods to continuum theory will be introduced.

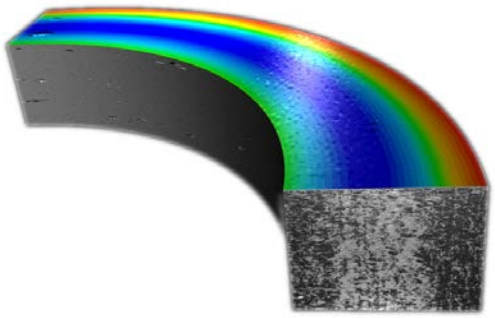
Local organization

The course is organized by the *Nonlinear Solid Mechanics* group and the *Multi-scale Mechanics* group, University of Twente, faculty of Engineering Technology, and the *Computational Mechanics* group, Delft University of Technology, Department of Civil Engineering and Geosciences.

Organizing committee:

- Ton van den Boogaard
- Stefan Luding
- Bert Sluys

Lecturers



- Ton van den Boogaard (UT)
- Remko Akkerman (UT)
- Stefan Luding (UT)
- Vanessa Magnanimo (UT)
- Semih Perdahcıoğlu (UT)
- Angelo Simone (TUD)
- Bert Sluys (TUD)
- Anthony Thornton (UT)
- Thomas Weinhart (UT)
- Javad Hazrati (UT)

Contents

- Vectors and tensors
- Kinematics (material coordinates, deformation & strain tensors, polar decomposition)
- Force and stress, Balance laws
- Fundamental concepts of constitutive equations (thermodynamics, frame indifference, elasto-viscoplasticity, yielding and hardening)
- Multi phase materials (phase transition, TRIP, composites, anisotropy)
- Plasticity models and continuum damage models (yield functions, damage loading functions, tangential formulation, return mapping, locking)
- Higher-order continua (non-local, gradient models, micro polar models)
- Deformation mechanics in composite laminates, extreme anisotropy and intraply shear locking
- Particle Methods (particle systems, molecular dynamics for particle systems, smooth particle hydrodynamics for continuum systems)
- Depth-averaged models (applied to granular systems)
- From Particle Systems to Continuum Theory (micro-macro transition methods, plastic flow models, higher order continua, advanced theories)
- Nonlinear solution techniques (Newton-Raphson methods, convergence criteria, Load-, displacement-, arc-length-control)
- Discontinuous models (weak/strong models (GFEM/XFEM), continuous-discontinuous models)

Lecture notes

Lecture notes will be distributed during the course.

Prerequisites

Basic undergraduate courses in Mathematics, Materials science, Mechanics of materials, Continuum Mechanics and the Finite Element Method.

Course assessment

Credits (3 EC) for this EM courses will be awarded on the basis of successful completion of a course assessment. Details regarding the assessment procedure will follow.

Location/date

Arrangements regarding COVID19:
Owing to the COVID19 outbreak this edition of the Engineering Mechanics course "Nonlinear Material Mechanics" will be provided online. Further details about the online setup of this course will be communicated to the registered participants in due time before the start of the course. The course language is English.

Fee/Registration

The course is free for registered members of the graduate school Engineering Mechanics and for the research members of the contributing research groups. They will receive an invoice after accepted registration. Participants need to register by completing the online registration form, which can be found under the following link: https://engineeringmechanics.nl/courses/
Deadline for registration, August 30th, 2021

Further information

On the contents and organization of the course:

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Further information about the educational programme and other activities of the Graduate School on Engineering Mechanics can be found at: https://engineeringmechanics.nl/courses/