

The logo consists of the lowercase letters 'em' in a grey, sans-serif font. A thin, curved orange line starts above the 'e', arches over the 'm', and extends to the right edge of the page.

Graduate course

MULTI-SCALE & MICROMECHANICS

November 2nd –November 4th
November 8th –November 10th

Mechanics of Materials
Department of Mechanical Engineering
Eindhoven University of Technology

4TU.



UCL
Université
catholique
de Louvain

The logo features a stylized blue flame above the text 'TU Delft' in a bold, blue, sans-serif font.

Technische Universiteit Delft

TU/e EINDHOVEN
UNIVERSITY OF
TECHNOLOGY

UNIVERSITEIT TWENTE.

General

This course is an initiative of the Dutch graduate school Engineering Mechanics with the support of the Belgian GrasMech graduate school. Research groups from different universities (TU/e, TU Delft, RuG, UCL) are actively contributing to this course. Besides theoretical and computational aspects of multi-scale and micromechanics, explicit attention will be given to related experimental analysis techniques in the field. This course is part of the 3TU Engineering Mechanics training programme for PhD students.

Objective

Multi-scale methods have contributed to a considerable progress in bridging the field of mechanics of materials to the field of materials science. This is mainly due to a fruitful combination of micromechanics and mathematical approaches, with a steadily increasing multi-disciplinary character. Several improved micromechanical theories and associated numerical models have been proposed and implemented, where a lot of interaction with materials science is involved. The developed understanding of single phases and complex interfaces in materials is optimally used in multi-scale techniques, where it is aimed to predict the collective multi-phase response of materials. Large deformations, damage and cracking, phase transformations, etc. can thereby be taken into account.

The objective of this EM graduate course on multi-scale and micromechanics is to provide a selective introduction into this wide interdisciplinary and expanding field of science. The course attempts to cover a variety of aspects in this field, where particular aspects in metals, polymers, composites, etc. will be addressed. Analytical and computational frameworks are presented and generic experimental techniques used to unravel processes at a single scale or establish relations across the scales are illustrated. Various methods, models and solution approaches will be advocated, emphasizing size effects, statistical effects, fracture, boundary effects, etc. along with their

impact on the response of engineering materials and/or micro-systems.

Local organization

The course is organized by the Mechanics of Materials group of the Mechanical Engineering Department of the TU/e. The local organizing committee is composed of

- Hans van Dommelen
 - Marc Geers (chairman)
 - Johan Hoefnagels
 - Varvara Kouznetsova
 - Marc van Maris
 - Ron Peerlings
-
- Alice van Litsenburg (group secretary)
 - Rachel van Outvorst (EM secretary)

Lecturers

Can Ayas

Delft University of Technology

Yoen van de Burgt

Eindhoven University of Technology

Issam Doghri

Université Catholique de Louvain

Hans van Dommelen

Eindhoven University of Technology

Marc Geers

Eindhoven University of Technology

Johan Hoefnagels

Eindhoven University of Technology

Markus Hütter

Eindhoven University of Technology

Varvara Kouznetsova

Eindhoven University of Technology

Regina Luttge

Eindhoven University of Technology

Francesco Maresca

Groningen University

Thomas Pardoën

Université Catholique de Louvain

Ron Peerlings

Eindhoven University of Technology

Olaf van der Sluis

Philips Research / Eindhoven University of Technology

Ye Wang

Eindhoven University of Technology

Lecture notes

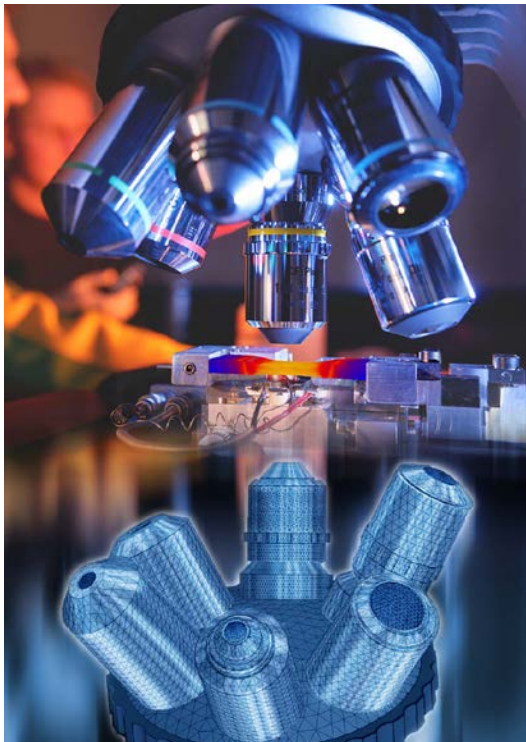
Lecture notes will be distributed during the course.

Poster session

An informal poster session will be organized on the first day of the course. This session aims to share all challenges in multi-scale and micromechanics from the perspective of the participants, providing a clear view of the background of all related research projects and individuals. All participants are invited to prepare a poster and present it on the first day.

Prerequisites

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



Contents

I SHORT INTRODUCTION

- Multi-scale & Micromechanics: overview
- mathematics & notations
- reminders of continuum mechanics

II MEAN-FIELD HOMOGENIZATION OF HETEROGENEOUS MATERIALS

- averaging and mean-field theories
- Eshelby and Mori-Tanaka approaches
- self-consistent methods
- cell methods

III SCALE TRANSITIONS

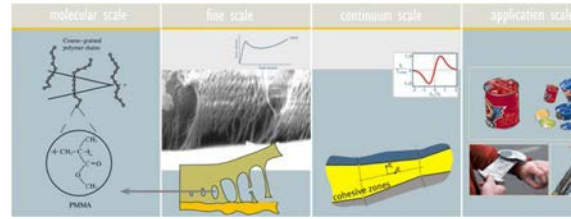
- asymptotic homogenization
- computational homogenization
- thermodynamics perspective on coarse graining

IV MICROPLASTICITY IN METALS

- discrete dislocation plasticity
- crystal plasticity: single and polycrystalline models
- scale size effects

V MICROMECHANICS OF SEMI-CRYSTALLINE MATERIALS

- multi-scale mechanics of semi-crystalline polymers



Multi-scale and Micromechanical aspects of cohesive interfaces

VI MECHANICS OF INTERFACES & THIN FILMS

- cohesive zone modeling
- thin film mechanics

VII ATOMISTIC MODELLING

- computational methods
- application to dislocations

VIII DUCTILE DAMAGE, CREEP, FATIGUE

- physics of ductile damage
- micromechanical modeling and characterization
- micromechanics of creep and fatigue

IX MICROSTRUCTURE EVOLUTION

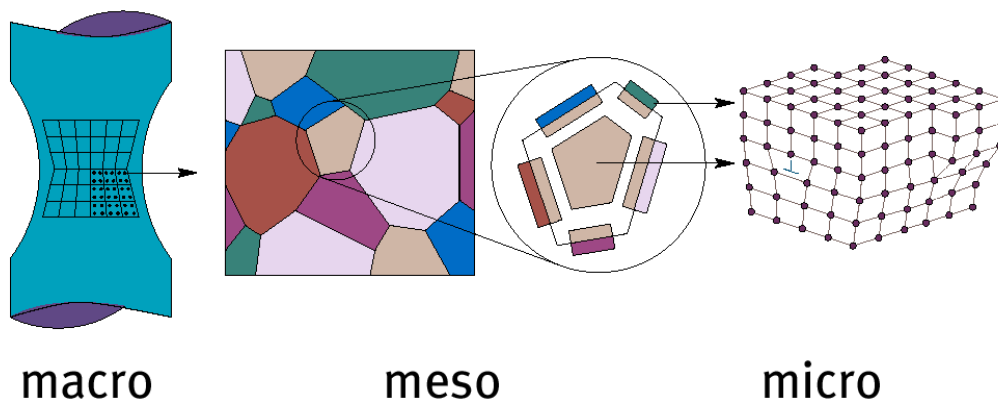
- introduction to phase field models

X EXPERIMENTAL MICROMECHANICS

- microscopy & analysis tools
- multi-scale testing

XI LAB and TRAINING SESSIONS

- related to the course subjects



Multi-scale mechanics in crystalline solids: from continuum to discrete lattice

Location/date

The course will take place at the Eindhoven University of Technology (Department of Mechanical Engineering) in two modules of three days each, i.e. November 2nd- 4th and November 8th - 10th 2022, respectively. The course language is English. A list of hotel accommodations in the vicinity of the course-location is available upon request. Participants are required to contact the hotels directly.

Further information

- On the contents of the course:
Prof.dr.ir. M.G.D. Geers, TU/e,
Tel.: +31- (0)40-247 50 76
E-mail: m.g.d.geers@tue.nl
- On the organization of the course:
Mrs. Rachel van Outvorst, TU/e,
Tel.: +31-(0)40-247 8306
E-mail: Engineering.Mechanics@tue.nl

Fee/Registration

The course is free for registered members of the graduate schools Engineering Mechanics and GrasMech and for the research members of the contributing research groups. The course fee for non-EM members is € 250 for PhD students and € 1000 for other participants. The fee includes lunch and coffee breaks, but does not include lodging and other meals. Participants will receive an invoice after accepted registration. Participants need to register via our website <https://engineeringmechanics.nl/courses/>

before October 15th, 2022

Members of the Graduate School Engineering Mechanics receive priority in case of over-subscription.

Upcoming courses

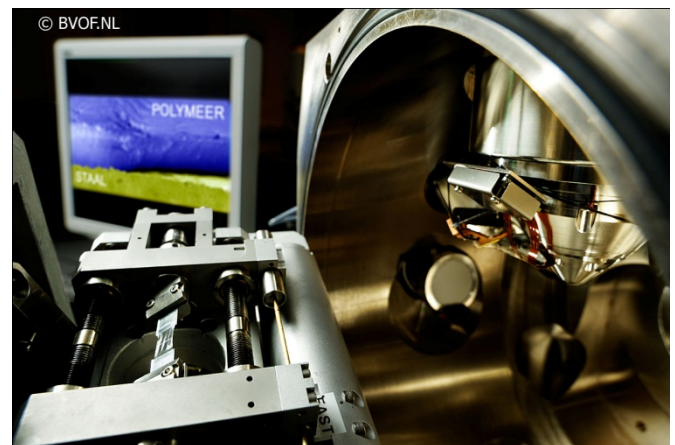
In addition to the present course, the Graduate School Engineering Mechanics organizes a series

of graduate courses on several subjects. For further information on these courses and on other activities of the Graduate School Engineering Mechanics please visit the WWW-pages at:

<http://www.engineeringmechanics.nl>
<https://engineeringmechanics.nl/courses/>

or contact:

Graduate School Engineering Mechanics,
c/o Eindhoven University of Technology,
Mrs. Rachel van Outvorst, P.O. Box 513,
Gem-Z 4.133, 5600 MB Eindhoven NL,
E-mail: Engineering.Mechanics@tue.nl,
Tel.: +31- (0)40-247 8306



Micro-loading stage mounted in a scanning electron microscope