



Graduate course

MULTI-SCALE & MICROMECHANICS

November 9th – November 11th
November 23rd – November 25th

Mechanics of Materials
Department of Mechanical Engineering
Eindhoven University of Technology

Arrangements regarding COVID19:

Owing to the COVID19 outbreak, the university campus will be closed until further notice. For this reason, this edition of the Engineering Mechanics course “Multi-scale and Micromechanics” 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

4TU.



university of
 groningen



UCL

Université
 catholique
 de Louvain

 **TU Delft**

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, RuG, TUDelft, 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 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
 - Marc van Maris
 - Ron Peerlings
 - Varvara Kouznetsova
-
- Alice van Litsenburg (group secretary)
 - Rachel van Outvorst (EM secretary)

Lecturers

Can Ayas

Delft 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

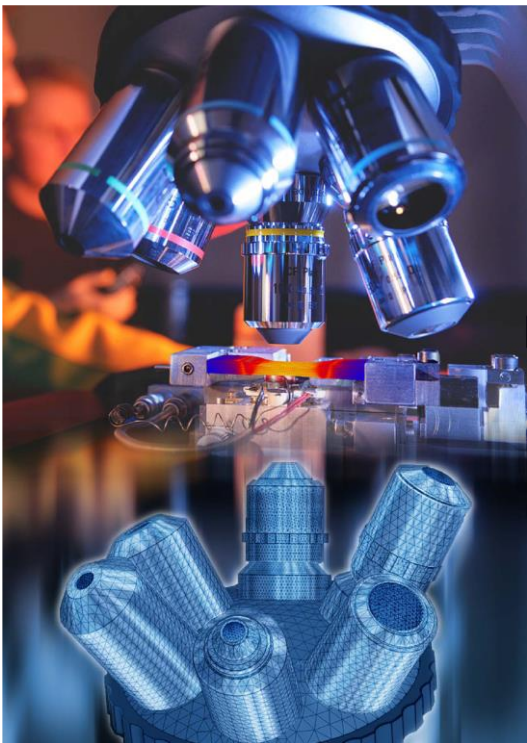
Philips Research / Eindhoven University of Technology

Lecture notes

Lecture notes will be made available in PDF during the course.

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

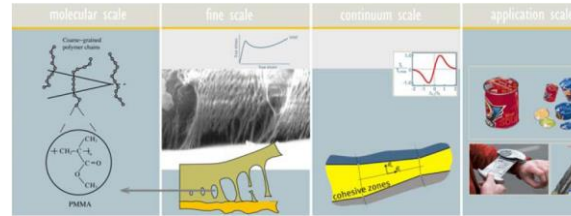
- asymptotic homogenization
- computational homogenization
- thermodynamics perspective on coarse graining

IV MICROPLASTICITY IN METALS

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

V MECHANICS OF INTERFACES & THIN FILMS

- cohesive zone modeling
- thin film mechanics



Multi-scale and Micromechanical aspects of cohesive interfaces

VI MOLECULAR DYNAMICS

- basic principles
- application aspects

VII DUCTILE DAMAGE, CREEP, FATIGUE

- physics of ductile damage
- micromechanical modeling and characterization

VIII MICROSTRUCTURE EVOLUTION

- introduction to phase field models

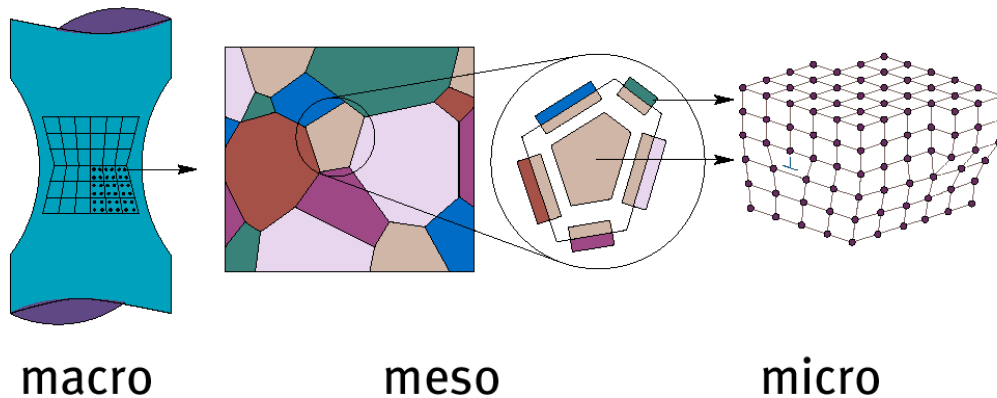
IX EXPERIMENTAL MICROMECHANICS

- microscopy & analysis tools
- multi-scale testing

X MICRO- AND NANOFABRICATION METHODS

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 be provided online in two modules of three days each, i.e. November 9th - 11th and November 23rd - 25th 2020, respectively. The course language is English. 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

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.

Registration

Participants need to register by completing the registration form, which can be found at the EM website on

<https://engineeringmechanics.nl/courses/#upcoming> and submit it **before October 26th, 2020**

Assessment

Those who wish to participate in the test must register before the deadline.

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:

www.engineeringmechanics.nl

<https://engineeringmechanics.nl/courses/#upcoming>

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