



# **Engineering Mechanics Graduate course**

*discontinuities, interfaces, fluid-structure interaction,  
multi-phase problems*

**May 14<sup>th</sup> – 16<sup>th</sup> 2018**

**Department of Mechanical Engineering  
Multiscale Engineering Fluid Dynamics  
Eindhoven University of Technology**

## General

Interfaces and discontinuities are ubiquitous in science and engineering. Typical examples are provided by multi-phase problems, boundary-coupled multi-field problems such as fluid-structure interaction, and cracks and discontinuities in solid materials. The characteristic feature of an interface is that it is spatially confined to a surface or to a very narrow region in the vicinity of a surface. In addition, most interface problems have a free-boundary character, which yields a complicated interdependence between the subsystems adjacent to the interface and the geometry of the interface.

This course provides an overview of various aspects of interface problems, with special emphasis on numerical-modeling techniques. Several different archetypal interface problems are considered, e.g., fluid-structure interaction, crack propagation, and damage mechanics. The course identifies the generic features of interface problems as well as the features specific to the various archetypes, in relation to numerical-modeling approaches.

The course has an informal character with ample opportunity for discussions with the lecturers and other participants.

## Local organization

The course is organized by the chair on Multiscale Engineering Fluid Dynamics at Eindhoven University of Technology (TU/e), in collaboration with the Mechanics of Materials section at TU/e. The course is hosted by Eindhoven University of Technology. The local organizing committee is composed of

- Prof. dr. ir. Harald van Brummelen
- Mrs. Linda Essink (secretary)

## Lecturers

- Dr. ir. Joris Remmers (TU/e, Mechanics of Materials)
- Dr. ir. Clemens Verhoosel (TU/e, Multiscale Engineering Fluid Dynamics)
- Prof. dr. ir. Harald van Brummelen (TU/e, Multiscale Engineering Fluid Dynamics)

## Lecture notes

Lecture notes and course material will be distributed at the start of the course.

## Prerequisites

Participation in the course is facilitated by basic familiarity with:

- partial differential equations and boundary-value problems;
- continuum mechanics;
- numerical techniques (notably, finite-element methods).

## Assessment

Starting 2018, credits for Engineering Mechanics courses will be awarded on the basis of successful completion of a course assessment. The assessment for this EM course will take place at the final day of the course. Details regarding the assessment procedure will be communicated during the course introduction lecture.

## Contents

The course is hosted by Eindhoven University of Technology, from Monday May 9<sup>th</sup> until Wednesday May 11<sup>th</sup>. The course consists of both lectures and computer-practical sessions. The course covers the following topics:

- 1) *An introduction to interface problems*  
The course starts with an introduction, characterizing the generic properties of interface problems, as well as the specific attributes pertaining to various prototype problems.
- 2) *Fluid-structure interaction*
  - a. Introduction to fluid and solid mechanics and fluid-solid interface conditions
  - b. Free boundaries, moving domains: three-field formulations
  - c. Partitioned solution procedures and added-mass effects
  - d. Variationally consistent load evaluation
  - e. Elasto-capillary fluid-solid interaction
- 3) *Crack propagation and the Partition of Unity Method*
  - a. Introduction to cracks and fracture mechanics
  - b. Cohesive zone models
  - c. Theory of the Partition of Unity Method for crack propagation
  - d. Implementation aspects of the Partition of Unity Method
- 4) *Isogeometric failure analysis: cohesive zones, damage mechanics and phase-field fractures*
  - a. Introduction to isogeometric analysis (IGA)
  - b. Interfacial continuity in IGA and its application to fracture mechanics
  - c. Higher-order damage mechanics and phase-field fracture analysis

## 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. The course fee for non EM members is € 100 for students and € 400 for other participants. They will receive an invoice after accepted registration. Participants need to register by completing the registration form, which can be found at <http://www.em.tue.nl/events/index.php/2/2018> (Deadline May 1<sup>st</sup>, 2018). Members of the Graduate School Engineering Mechanics receive priority in case of over-subscription.

## Further information

Arrangements regarding dinners and accommodation will be communicated to the course participants by email prior to the course.

For more information on the contents of the course, contact:

Prof.dr.ir. Harald van Brummelen, TU/e  
E-mail: [e.h.v.brummelen@tue.nl](mailto:e.h.v.brummelen@tue.nl)

Further information about the educational programme and other activities of the Graduate School on Engineering Mechanics can be found at: [www.em.tue.nl](http://www.em.tue.nl).