

## Course Description

The course will concentrate on theory and practice of topology design. Topics include:

- Design parametrization (interpolation schemes, composites, etc.)
- Sensitivity analysis (direct and adjoint methods)
- Algorithms (OC-methods, mathematical programming, convex approximation schemes and other methods)
- Computational issues (checkerboards, filters, robust design, parallelization)
- Applications in structural and multi-physics problems (industrial examples, MicroElectroMechanical Systems (MEMS), wave-propagation problems)

The course work includes study of preparatory reading material before course-start (see below).

An integral part of the course is computer exercises and preparing a poster for presentation on the last day of the course; exercise work is planned for the weekend.

All participants are also required to bring a poster on the topic of their Ph.D. research work.

## Course homepage

[http://www.kurser.dtu.dk/41591.aspx?menulanguage=en\\_gb](http://www.kurser.dtu.dk/41591.aspx?menulanguage=en_gb)  
<http://www.dcammm.dk>.

## Organizers

Ole Sigmund, Department of Mechanical Engineering, Technical University of Denmark

Jakob Søndergaard Jensen, Department of Mechanical Engineering, Technical University of Denmark

Mathias Stolpe, Department of Wind Energy, Technical University of Denmark

Anton Evgrafov, Department of Applied Mathematics and Computer Science, Technical University of Denmark

## Participants

The course is designed for Ph.D.-students and final-year graduate students being familiar with the basic concepts of the finite element method. Knowledge corresponding to a course in FEM as well as Matlab experience is assumed.

## Working Load

Approximately 100 hours in total, including work during the June 19–25 course period at DTU (lectures, exercises, discussions, seminars) as well as preparatory required reading before course start.

## Study Material

The course textbook is:

Martin P. Bendsøe and Ole Sigmund (2003 and 2004), "Topology Optimization: Theory, Methods and Applications." Springer Verlag, 2003 or 2004, ISBN 3-540-42992-1.

Preparatory reading consists of Chapter 1 and Appendix 5.1.

## Internet Resources

For facts on the Technical University of Denmark and visitor's information: see <http://www.dtu.dk>. For information about teaching and research at the DCAMM departments: see <http://www.dcammm.dk>.

## Language

All lectures will be given in English

## Evaluation and Diplomas

To pass the course, active participation in all activities is required; this includes the exercises, the poster session, and the student presentations.

Grades: Pass/Fail. ECTS points: 3.5

## Registration

DTU students should register on CampusNet (from May 1<sup>st</sup>). If you are not a DTU student you should register as a guest PhD Student at DTU on the following link:

[https://www.dtu.dk/English/education/Phd\\_Education/Guest\\_%20Phd-student/Registration.aspx](https://www.dtu.dk/English/education/Phd_Education/Guest_%20Phd-student/Registration.aspx)

If you have any questions regarding registration or accommodation, please contact: Kari Haugland, Department of Applied Mathematics and Computer Science, Technical University of Denmark, Building 303S, DK-2800 Kgs.Lyngby, Denmark. Tel.: (+45) 45253031, Fax: (+45) 45881399,

E-mail: [k.haugland@mat.dtu.dk](mailto:k.haugland@mat.dtu.dk).

## Registration fee:

There is no registration fee for students enrolled at universities and public research institutions. For researchers employed at universities and public research institutions the registration fee is 350 EURO. This covers hand-outs, coffee and social events. For all other participants the registration fee is 1050 EURO.

## Deadline:

Applicants should submit a request for registration to be at the hands of the course secretariat no later than May 15, 2013. You will receive confirmation within a week after this date.

## Accommodation

There are a limited amount of rooms available on the premises of the Technical University of Denmark (contact K. Haugland). These can be rented at approx. 25 Euro per night.

Otherwise accommodation should be arranged by the participants themselves. See hostels/hotels in Lyngby and the official tourist site:

<http://lyngbyhostel.dk/?lang=en>

<http://www.fortunen.dk/>

<http://www.post-pub.s-10.dk/default.asp?pid=70>

<http://www.scandichotels.com/eremitage>

[http://www.visitcopenhagen.com/tourist/plan\\_and\\_book/accommodation](http://www.visitcopenhagen.com/tourist/plan_and_book/accommodation)

## Program outline (TENTATIVE):

### Wednesday, June 19:

08.30-09.00 Registration and coffee and rolls.  
09.00-09.15 Welcome - practicalities  
9.15-12.00 The basics of topology optimization - the direct approach (O. Sigmund, OS).  
13.30-17.30 Introduction to computer exercises (J. Søndergaard Jensen, JSJ).  
18.30 Pizza-get-together

### Thursday, June 20:

08.30-09.00 Coffee and rolls.  
09.00-10.00 Projection filters and robust design (Mattias Schevenels, KU Leuven)  
10.30-12.00 Mathematical programming. (Mathias Stolpe, MS and Anton Evgrafov, AE).  
13.30-14.30 Intro to Mathematical programming exercises.  
14.30-17.30 Computer exercises.

### Friday, June 21:

08.30-09.00 Coffee and rolls.  
09.00-10.30 Design of mechanisms, materials, and MEMS (OS)  
11.00-12.00 Discrete vs. continuous adjoints (AE)  
13.30-15.00 Computer exercises.  
15.00-16.00 A historical perspective: existence of solutions, composites and homogenization (Martin P. Bendsøe)  
16.00-17.30 Poster session (by participants).

### Saturday and Sunday, June 22 and 23:

Work on exercises (on your own).

### Monday, June 24:

08.30-09.00 Coffee and rolls.  
09.00-10.30 Design in vibration and wave propagation (JSJ)  
11.00-12.00 Phase field methods (Mathias Wallin, Sweden)  
13.30-14.30 Industrial applications.  
(Claus B.W. Pedersen, FE-DESIGN)  
16.15-18.00 Computer Exercises.  
19.30 Dinner in a local restaurant.

### Tuesday, June 25:

08.30-09.00 Coffee and rolls.  
09.00-10.00 Design of fluid systems. (Casper S. Andreasen)  
10.15-11.00 Alternatives to the density approach (OS)  
11.15-12.15 Large scale topology optimization and parallel computing (Niels Aage)  
13.30-14.30 Course evaluation.  
14.30-16.00 'Poster' presentations of exercise work.



## DANISH CENTER FOR APPLIED MATHEMATICS AND MECHANICS

The Danish Centre for Applied Mathematics and Mechanics, DCAMM, is an informal framework for internationally oriented scientific collaboration between staff members at a number of departments at the Technical University of Denmark (DTU) Aalborg University (AAU) and Aarhus University (AU). The Departments cooperating within DCAMM are:

- Dept. of Department of Applied Mathematics and Computer Science
- Dept. of Mechanical Engineering, DTU
- Dept. of Wind Energy, DTU
- Dept. of Civil Engineering, AAU
- Dept. of Mechanical and Manufacturing Engineering, AAU
- Dept. of Engineering, AU

DCAMM is an informal construction that was founded October 27, 1969. The day to day activities are coordinated by the chairman of the Center (pt. associate professor [Christian Niordson](#), Department of Mechanical Engineering, Solid Mechanics), while the formal governing body of DCAMM is the Scientific Council.

Ph.D.-course / Advanced school  
Course no. 41591

## Topology Optimization - Theory, Methods and Applications

at

Technical University of Denmark,  
Lyngby, Denmark

June 19-25, 2013

Organized by:

Department of Mechanical Engineering,  
Department of Applied Mathematics and Computer  
Science

and

Department of Wind Energy,  
Technical University of Denmark

