

# 2D1260 Finite Element Methods: Fall 2006

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The goal of this course is to give basic knowledge of the theory and practice of the finite element method and its application to the partial differential equations of physics and engineering sciences. The purpose is to give a balanced combination of theoretical and practical skills. The theoretical part is mainly concerned with the derivation of finite element formulations as well as estimating the discretization error and how to use error estimates to adaptively refine the mesh (see [www.fenics.org/gallery/](http://www.fenics.org/gallery/) and [www.bodysoulmath.org/body.shtml](http://www.bodysoulmath.org/body.shtml) for examples). The practical part deals with computer implementation: element matrices, assembly, numerical integration, etc.

## Course Homepage

All relevant information for the course is available at the course homepage; such as this project pm, lecture plan, extra problems with solutions, old exams, etc. Note that the homepage will change during the course, so be sure to check back regularly for up to date information:

<http://www.csc.kth.se/utbildning/kth/kurser/2D1260/fem06/>

## Teachers

- Coordinator and lecturer is Johan Hoffman ([jhoffman@csc.kth.se](mailto:jhoffman@csc.kth.se)).
- Teaching assistant is Erik von Schwerin ([schwerin@csc.kth.se](mailto:schwerin@csc.kth.se)).

## Office Hours

- Johan Hoffman (room 4526): Mondays 9.00-10.00
- Erik von Schwerin (room 4520): Tuesdays 9.00-10.00

In case there is teaching (lectures, excercises, computer sessions) these hours, the office hours are cancelled.

## Examination

The total grade of this course will be the mean value of the grade of a written exam and a project (rounded up):

- **Written exam:** Saturday October 21, 8-13.
- **Project:** Report A should be handed in by Friday September 22, and Report B by Friday October 20. The project should be carried out individually or in groups of two.

2 sets of problems generate maximum 5 bonus points for the written exam if handed in by Friday September 22 (Problem set A) and by Friday October 20 (Problem set B):

- **Problem set A:** 8.13, 15.19, 15.20, 15.21, 15.22
- **Problem set B:** 8.22, 15.45(a,b), 15.48, 15.49, 21.8

## Literature

Course book: *Computational Differential Equations*, by K. Eriksson, D. Estep, P. Hansbo, C. Johnson. Studentlitteratur, ISBN ISBN 91-44-49311-8. Price: 410 kr at kårens bokhandel.

## Preliminary weekly plan

### Week 1

- Lecture 1: Wed 30 Aug, 8-10; E3  
Poisson 1D, boundary conditions, weak formulation, Galerkin method, piecewise polynomials 1D  
(CDE 1-4,6,8.1)
- Lecture 2: Thu 31 Aug, 8-10; E3  
Poisson 2D, assembly algorithm, FEM mesh, piecewise polynomials 2D, quadrature, affine mapping, implementation in Puffin  
(CDE 5.5,(7),13,14.1-14.2,14.4,15.1)

- Lecture 3: Fri 1 Sep, 8-10; V2  
Boundary conditions, adaptivity, residual, mesh refinement  
(CDE 15.1,15.3,15,4)

## Week 2

- Exercise 1: Mon 4 Sep, 15-17; E51, E52
- Exercise 2: Tue 5 Sep, 15-17; D31, D32
- Exercise 3: Wed 6 Sep, 8-10; E31, E32
- Exercise 4: Thu 7 Sep, 10-12; D52, E53
- Computer session 1: Fri 8 Sep, 8-10; 4V4Gul, 4V6Bru  
Project A

## Week 3

- Lecture 4: Tue 12 Sep, 15-17; E3  
Interpolation, error estimation, higher order FEM  
(CDE 5,8.2-8.6,14.2,15.2-15.3)
- Lecture 5: Wed 13 Nov, 8-10; E2  
Adaptivity, a priori, a posteriori, duality  
(CDE 15.5)
- Lecture 6: Thu 14 Nov, 10-12; E3  
Abstract problem, Lax-Milgram  
(CDE 21,12)
- Computer session 2: Fri 15 Sep, 13-15; 4V4Gul, 4V6Bru  
Project A

#### Week 4

- Exercise 5: Thu 19 Sep, 15-17; E33, E34
- Lecture 7: Wed 20 Sep, 8-10; E2  
Initial value problem, heat equation, wave equation, stability, theta-method  
(CDE 9.1-9.2,16,17)
- Computer session 3: Thu 21 Sep, 15-17; 4V4Gul, 4V6Bru  
Project A
- Submit Project A and Problems A, Fri 22 Sep.

#### Week 5

- Lecture 8: Tue 26 Sep, 15-17; E3  
Convection-diffusion-reaction equation, space-time FEM, stabilization  
(CDE 18,19)
- Exercise 6: Wed 27 Sep, 8-10; E32, E33
- Computer session 4: Thu 28 Sep, 15-17; 4V4Gul, 4V6Bru  
Project B

#### Week 6

- Computer session 5, Mon 2 Oct, 8-10; 5O1Spe, 5O2Spo  
Project B
- Exercise 7: Tue 3 Oct, 15-17; D31, D32
- Lecture 9: Wed 4 Oct, 10-12; M3  
ALE, Navier-Stokes, overview/repetition  
(CDE )
- Computer session 6: Thu 5 Oct, 15-17; 4V4Gul, 4V6Bru  
Project B

**Week 7**

- Time for work on Project B and Problem B.

**Week 8**

- Submit Project B and Problems B, Fri 20 Oct.
- Written exam: Sat 21 Oct, 8-13 (D31, D32, D33, D34, D35, 4V4Gul, 4V6Bru).