Chalmers University of Technology Department of Industrial and Materials Science

TME250 Finite Element Method - Solids

7.5 credit points, Ouarter 2, fall semester 2019

Instructors

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General purpose and contents

The aim is to provide the student with further understanding of the nature of the Finite Element Method (FEM), in particular its approximate character, and to provide extended skill in applying FEM to engineering problems related to solid mechanics. Hence, the course builds on knowledge acquired in continuum mechanics (mechanics of solid bodies), material modeling and the application of FEM to basic problems. These topics are covered in the courses Mechanics of Solids TME235, Material Mechanics MHA042 and TME245 Finite Element Method – Structures. Computer assignments play a key role as the means of implementing and assessing models and algorithms.

Approximately 18 lectures will comprise the following topics:

- Linear elasticity: Some fundamentals
- Linear elasticity: Mixed methods, in particular for the incompressible limit
- Nonlinear elasticity: Finite deformation theory
- Contact mechanics
- Multifield/coupled problems: thermomechanics
- Linear elasticity: Error analysis and adaptive methods

Course web page

All course information, including handed out material and the updated schedule will be available on the course webpage on CANVAS. Add a bookmark!

Organization of lectures and lab classes

The course comprises lectures in accordance with the schedule available on the course web page. In addition, computer rooms are booked for the course for 4 hours per week. Each of the four computer assignment will be introduced in the computer classes according to the schedule.

Course work and examination

The main course work consists of four computer assignments (CA1-CA4) involving FE-computation using Matlab (CALFEM) and a final written exam.

The Calfern package can be downloaded from http://sourceforge.net/projects/calfem/

The topics of the CA's are as follows:

- CA1: Incompressible elasticity (2 credit points)
- CA2: Contact mechanics (2 credit points)
- CA3: Finite elasticity (3 credit points)
- CA4: Error-control and adaptivity for linear elasticity (2 credit points)

An informal written report for each assignment must be submitted before the deadline given in the schedule. The assignments are graded and will then give maximum credit points as indicated above. Altogether, **9 credit points** can thus be obtained towards the final grade, see below. These points will remain valid until the course is given next time.

The final written exam is based on quizzes and problems that will accompany the lectures and will be put on the course homepage during the course. No aids are permitted during the final written exam. The exam comprises questions/problems of theoretical character. Altogether, **9 points** can thus be obtained towards the final grade, see below.

Grades are awarded as follows:

Collected credit points	Chalmers grade
0-9	U
10-12	3
13-15	4
16-18	5

To complete the course, it is thus **necessary to participate in computer assignments and complete the final exam**.

Course evaluation

A continuous evaluation will be held during and after the course consisting of three meetings: one introductory meeting during the first week, a mid-course meeting in the fourth week and a final evaluation after the course. A group of students are chosen at the first lecture to represent the class at the meetings. The goal of the mid-course meeting is to assess the current status of the course while the final meeting aims at developing the course for next year. We greatly appreciate your feedback! In-between the written exam and the final evaluation meeting, a questionnaire will be sent out to all course participants.

Literature

[1] M. Ekh, R. Jänicke, F. Larsson and K. Runesson, The Finite Element Method – Solid Mechanics. Department of Industrial and Materials Science, Chalmers University of Technology, 2018. (in preparation). **Selected chapters**.¹

[2] N.S. Ottosen and H. Peterson. *Introduction to the finite element method*. Prentice –Hall, New York 1992.

[3] Fredrik Larsson. *Nonlinear finite element analysis – A short introduction*. Dept. of Applied Mechanics, Chalmers, 2010. ¹

[4] P-E. Austrell, O. Dahlblom, J. Lindemann, A. Olsson, K-G. Olsson, K. Persson, H. Petersson, M. Ristinmaa, G. Sandberg and P-A. Wernberg, *CALFEM, A Finite element toolbox to MATLAB, Version 3.4.* Dept. of Structural Mechanics and Solid Mechanics, Lund 2004.²

[5] Kenneth Runesson, Paul Steinmann, Magnus Ekh and Andreas Menzel , Tensor Calculus Toolbox, Excerpt from Constitutive Modeling of Engineering Materials –Theory and Computation, Chalmers University of Technology, 2011.¹

¹ The pertinent chapters will be available on the course homepage (CANVAS) for individual downloading. Hence there is no cost other than printing paper.

² Available for downloading in electronic format at

http://www.solid.lth.se/fileadmin/hallfasthetslara/utbildning/k
urser/FHL064_FEM/calfem34.pdf

TME250 Finite Element Method - Solids

Course Schedule

Mon, A/11 10 ⁶ , 11 ⁴ ML14 Lecture 2 Course Intro. Elasticity FL FL <th>W1</th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th>	W1						
Wed. 6.11 10 ⁶ , 11, ⁶ M124 Lecture 2 Linear elasticity FL [1], Ch3 M10, M17 Certure 3 Linear elasticity FL [1], Ch3 M0, 11/1 10 ⁶ , 11 ⁶ M10, M17 Exeruse Fambout CA1 FL W2 M10, M17 Exeruse Linear elasticity FL [1], Ch3 M0, 11/1 10 ⁶ , 11 ⁶ M10, M17 Exeruse FR [1], Ch3 M0, 13/1 10 ⁶ , 11 ⁶ M10, M17 Exeruse FR [1], Ch3 W3 T Lecture 4 Linear elasticity FL [1], Ch3 W3 T M10, M17 Exeruse FE [1], Ch3 W64, 20/1 10 ⁶ , 11 ⁶ M10, M17 Exeruse FE [1], Ch3 M114 Lecture 5 Contact problems RJ [1], Ch3 [1], Ch3 M15 M14 Lecture 5 Contact problems FL [1], Ch3 M15 M14 Lecture 10 Non-linear elasticity, finite deformations FL [1], Ch3 M16 Lecture 13 Non-linear elasticity, finite de	Mon, 4/11	10^{00} - 11^{45}	ML14	Lecture 1	Course Intro. Elasticity	FL, RJ	[1], Ch3
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Wed, 6/11	10 ⁰⁰ -11 ⁴⁵	ML14	Lecture 2	Linear elasticity	FL	[1], Ch3
15 ²³ -17 ³⁰ M10, M19 Exercise Mon, 11/11 Hand-out CA1 FE Mon, 11/11 08 ⁴⁰ 09 ⁴⁰ 10 ¹⁰ , 11 ⁴⁰ M14 Lecture 4 Linear elasticity FL [1], Ch3 Wed, 13/11 10 ¹⁰ , 11 ⁴⁰ M114 Lecture 5 Linear elasticity FL [1], Ch3 M13 15 ¹⁰ , 11 ⁴⁰ M114 Lecture 5 Non-linear elasticity FL [1], Ch3 Man, 18/11 05 ¹⁰ , 01 ⁴¹ M10, M19 Exercise Contact problems R1 [1], Ch10 13 ¹⁰ , 11 ⁴⁰ M114 Lecture 5 Contact problems R1 [1], Ch10 13 ¹⁰ , 11 ⁴⁰ M114 Lecture 5 Contact problems R1 [1], Ch10 13 ¹⁰ , 11 ⁴⁰ M114 Lecture 5 Contact problems R1 [1], Ch10 13 ¹⁰ , 11 ⁴⁰ M114 Lecture 5 Contact problems R1 [1], Ch10 13 ¹⁰ , 11 ⁴⁰ M114 Lecture 10 Non-linear elasticity, finite deformations FL [1], Ch5 13 ¹⁰ , 11 ⁴⁰ M10, M19 Exercise		13^{15} - 15^{00}	ML14	Lecture 3	Linear elasticity	FL	[1], Ch3
W2 Mon, 11/11 08 ⁴⁰ 09 ⁴⁴ ML14 Lecture 4 Linear elasticity FL [1]. Ch3 Wed, 13/11 10 ⁶⁰ -11 ⁴⁵ ML14 Lecture 5 Linear elasticity FL [1]. Ch3 Wed, 13/11 10 ⁶⁰ -11 ⁴⁵ ML14 Lecture 5 Linear elasticity FL [1]. Ch3 Main 13 ⁸¹ -15 ⁴⁰ ML14 Lecture 7 Contact problems R1 [1]. Ch10 Mon, 18/11 08 ⁶⁰ -09 ⁴⁰ ML14 Lecture 8 Contact problems R1 [1]. Ch10 13 ⁶¹ -15 ⁴⁰ ML14 Lecture 8 Contact problems R1 [1]. Ch10 13 ⁶¹ -15 ⁴⁰ ML14 Lecture 10 Contact problems R1 [1]. Ch10 13 ⁶¹ -15 ⁴⁰ ML14 Lecture 12 Contact problems R1 [1]. Ch10 13 ⁶¹ -15 ⁴⁰ ML14 Lecture 13 Non-linear elasticity, finite deformations FL [1]. Ch5 14 ⁶¹ ML14 Lecture 13 Non-linear elasticity, finite deformations FL [1]. Ch5 14 ⁶¹ ML24 Lecture 13 Non-linear elasticity, finite deformations FL [15^{15} -17 ⁰⁰	MTO, MT9	Exercise	Hand-out CA1	FE	
Mon, 11/1108°-094° 10°-114° 10°-114° 10°-114° 10°-114° 10°-114° 10°-114° 	W2						
10 ⁶⁰ 11 ⁴⁵ 10 ⁶⁰ 11 ⁴⁶ MI.14 MI.14 MI.14 Exercise Lecture 5 MI.14 Lecture 6 Moninear elasticity Moninear elasticity Moninear elasticity MI.14 FL [1]. Chi II. Chi II	Mon, 11/11	08 ⁰⁰ -09 ⁴⁵	ML14	Lecture 4	Linear elasticity	FL	[1], Ch3
Wed, 13/11 10 ⁶ , 11 ⁻⁶ ML14 Lecture 5 Linear elasticity FL [1], ch3 Non 15 ⁻⁶ , 11 ⁻⁶ MU14 Lecture 5 Non linear elasticity FL [1], ch3 Wa U 0 ⁶⁰⁻⁰ , 11 ⁻⁶ ML14 Lecture 7 Contact problems RJ [1], ch3 Mon, 18/11 0 ⁶⁰⁻⁰ , 11 ⁻⁶ ML14 Lecture 8 Contact problems RJ [1], ch10 13 ^{10-15¹⁰} ML14 Lecture 9 Contact problems RJ [1], ch10 13 ^{10-15¹⁰} ML14 Lecture 9 Contact problems FL [1], ch10 13 ^{10-15¹⁰} ML14 Lecture 10 Non linear elasticity, finite deformations FL [1], ch5 FL, 2211 10 ^{60-11⁻⁶} ML14 Lecture 11 Non linear elasticity, finite deformations FL [1], ch5 Md12 Lecture 13 Non linear elasticity, finite deformations FL [1], ch5 Md14 Lecture 13 Non linear elasticity, finite deformations FL [1], ch12 Md14 Lecture 13 Non linear elasticity, finite deformations FL [1], ch12		10^{00} - 11^{45}	MT0, MT9	Exercise		FΕ	
13 ¹⁵ .15 ¹⁰ M1.4 Lecture 6 Non-linear elasticity FL [1], Ch4 W3 W	Wed, 13/11	10 ⁰⁰ -11 ⁴⁵	ML14	Lecture 5	Linear elasticity	FL	[1], Ch3
N3 FE W3 W10, MT9 Exercise FE Wa, 18/1 08 ⁰ -09 ⁻⁵ M.14 lecture 7 Contact problems R1 [1], Ch10 Map M.14 Lecture 8 Contact problems R1 [1], Ch10 FE Wed, 20/11 10 ^{07,11⁻⁶ M.14 Lecture 9 Contact problems R1 [1], Ch10 13^{5,1,17⁰⁰} M.14 Lecture 9 Contact problems FL [1] (1, Ch10 W11 17⁰⁰ M.14 Lecture 10 Non-linear elasticity, finite deformations FL [1], Ch5 M10, M19 Exercise M10, M19 Exercise Non-linear elasticity, finite deformations FL [1], Ch5 15^{5,1,17⁰⁰} M10, M19 Exercise Non-linear elasticity, finite deformations FL [1], Ch5 15^{5,1,17⁰⁰} M10, M19 Exercise Non-linear elasticity, finite deformations FL [1], Ch5 15^{5,1,17⁰⁰} M10, M19 Exercise Non-linear elasticity, finite deformations FL [1], Ch10 Wed, 4/12 10^{07,116} M10, M19 Exercise <}		$13^{15} - 15^{00}$	ML14	Lecture 6	Non-linear elasticity	FL	[1], Ch4
W3 Mon, 18/11 08 ³⁰ , 09 ⁷⁵ ML14 Lecture 7 Contact problems R J [1], Ch10 10 ³⁰ , 11 ⁶⁴ M14 Lecture 8 Contact problems R J [1], Ch10 13 ^{15, 15⁷⁰} M14 Lecture 9 Contact problems R J [1], Ch10 13 ^{15, 15⁷⁰} MT0, MT9 Exercise Hand-out CA2 FE Fri, 22/11 17 ⁶⁰ MT0, MT9 Exercise Hand-out CA2 FE Wd 10 ^{51, 170} MT0, MT9 Exercise FE Hand-out CA2 FE Wd 10 ^{51, 170} M10, MT9 Exercise Non-linear elasticity, finite deformations FL [1], Ch5 13 ^{11, 15⁵⁰} M114 Lecture 10 Non-linear elasticity, finite deformations FL [1], Ch5 13 ^{11, 15⁵⁰} M114 Lecture 13 Non-linear elasticity, finite deformations FL [1], Ch12 13 ^{11, 15⁵⁰} M114 Lecture 14 Coupled problems:Thermoelasticity RJ [1], Ch15 15 ^{12, 17⁷⁰} MT0, MT9 Exercise FC [1], Ch15 [1], Ch15 15 ^{12, 1}		15^{15} -17 ⁰⁰	MTO, MT9	Exercise		FE	
Mon, 18/11 00 ³⁰ -09 ⁴⁵ MT0, MT9 MT14 Leture 7 Contact problems RJ [1], Ch10 Wed, 20/11 10 ³⁰ -11 ⁴⁵ MT14 Lecture 8 Contact problems RJ [1], Ch10 13 ¹⁵ -15 ³⁰ MT14 Lecture 8 Contact problems RJ [1], Ch10 15 ¹⁵ -17 ³⁰ MT0, MT9 Exercise Contact problems RJ [1], Ch10 77 MT0, MT9 Exercise Contact problems FL [1], Ch10 77 MT0, MT9 Exercise Contact problems FL [1], Ch5 10 ³⁰ -11 ⁴⁵ MT14 Lecture 10 Non-linear elasticity, finite deformations FL [1], Ch5 13 ¹⁵ -17 ³⁰ MT14 Lecture 13 Non-linear elasticity, finite deformations FL [1], Ch5 10 ³⁰ -11 ⁴⁵ MT14 Lecture 13 Non-linear elasticity, finite deformations FL [1], Ch5 10 ³⁰ -11 ⁴⁵ MT14 Lecture 13 Non-linear elasticity, finite deformations FL [1], Ch10 10 ³⁰ -11 ⁴⁵ MT14 Lecture 14	W3						
10 ⁰⁰ 11 ⁴⁵ M10, MT9 Exercise FE Wed, 20/11 10 ⁰⁰ 11 ⁴⁵ Lecture 8 Contact problems RJ [1], Ch10 13 ⁴⁵ 15 ⁶⁰ M14 Lecture 9 Contact problems RJ [1], Ch10 15 ⁴⁵ 17 ⁴⁰ MT0, MT9 Exercise Hand-out CA2 FE Fri, 22/11 10 ⁶⁰ 10 ⁶⁰ MT0, MT9 Exercise Non-linear elasticity, finite deformations FL [1], Ch5 Wd 10 ⁶⁰ 11 ⁴⁵ MT0, MT9 Exercise Non-linear elasticity, finite deformations FL [1], Ch5 13 ⁴⁵ 15 ⁶⁰ MT4 Lecture 13 Non-linear elasticity, finite deformations FL [1], Ch5 M5 10 ⁶⁰ MT0, MT9 Exercise Kan-bin-bit Kan-bit	Mon, 18/11	08 ⁰⁰ -09 ⁴⁵	ML14	Lecture 7	C ontact problems	R J	[1], Ch10
Wed, 20/11 10 ⁰⁰ , 11 ⁴⁵ ML14 Lecture 8 Contact problems Ri [1], Ch10 15 ¹⁵ , 17 ¹⁰ MU14 Lecture 9 Contact problems RJ [1], Ch10 15 ¹⁵ , 17 ¹⁰ MU0, MI14 Lecture 9 Contact problems RJ [1], Ch10 15 ¹⁵ , 17 ¹⁰ MU0, MI14 Lecture 10 Non-linear elasticity, finite deformations FL [1], Ch5 13 ¹⁵ , 15 ¹⁰ ML14 Lecture 13 Non-linear elasticity, finite deformations FL [1], Ch5 13 ¹⁵ , 15 ¹⁰ ML14 Lecture 13 Non-linear elasticity, finite deformations FL [1], Ch5 13 ¹⁵ , 15 ¹⁰ ML14 Lecture 13 Non-linear elasticity, finite deformations FL [1], Ch5 13 ¹⁵ , 15 ¹⁰ ML14 Lecture 13 Non-linear elasticity, finite deformations FL [1], Ch5 13 ¹⁵ , 17 ¹⁰ ML14 Lecture 13 Non-linear elasticity, finite deformations FL [1], Ch5 13 ¹⁵ , 17 ¹⁰ ML14 Lecture 13 Non-linear elasticity, finite deformations FL [1], Ch15		10 ⁰⁰ -11 ⁴⁵	MTO, MT9	Exercise		FΕ	
13 ¹⁰ -15 ⁵⁰ ML14 Lecture 9 Contact problems R J [1], Ch10 Fri, 22/11 17 ⁰⁰ M10, MT9 Exercise Hand-out CA2 FE W4	Wed, 20/11	10 ⁰⁰ -11 ⁴⁵	ML14	Lecture 8	C ontact problems	R J	[1], Ch10
Fri 2211 Fri 2700MT0, MT9Exercise Hand-out CA2 Hand-in CA1FEFri 2211 W4TotoSecondFL[1], Ch5 FEMon, 25/11 100°-11"5ML14 110, MT9 13"5.150Lecture 10 Lecture 11Non-linear elasticity, finite deformations Non-linear elasticity, finite deformations FLFL[1], Ch5 FEWed, 27/11MC14 13"5.150Lecture 11 ML14Non-linear elasticity, finite deformations Hand-out CA3FL[1], Ch5 FEWed, 27/11MC0Exercise ML14Non-linear elasticity, finite deformations Hand-out CA3FL[1], Ch5 FEMon, 27/12D68°0.09"5 10°".11"6ML14 ML14Lecture 13 Lecture 13Non-linear elasticity, finite deformations Coupled problems: Themoelasticity RIFL[1], Ch5 FEMon, 27/12D68°0.09"5 10°".11"6ML14 Lecture 14 Lecture 15Coupled problems: Themoelasticity RIRI[1], Ch10 FEWed, 4/12D69°.19"6 13".17"0ML14 ML14Lecture 16 ExerciseFror analysis Hand-out CA2FL[1], Ch15 FEWed, 11/12D69°.19"6 13".17"0ML14 ML14Lecture 16 ExerciseFror analysis Hand-out CA4FL[1], Ch15 FEWed, 11/12D69°.19"6 13".17"0ML14 ML14Lecture 18 Lecture 18 Hand-out CA4FL[1], Ch15 FEWed, 18/1210°°.11"6 10°°.11"6ML14 ML14Lecture 19 Lecture 19Fror analysis Hand-out CA4FL[1], Ch15 FEWed, 18/1217°0ML14<		13 ¹⁵ -15 ⁰⁰	ML14	Lecture 9	C ontact problems	RJ	[1], Ch10
Fri, 22/1117°°Hand-in CA1W4VVVVMon, 25/11M14Lecture 10Non-linear elasticity, finite deformationsFL[1], ChSMon, 25/11M14Lecture 11Non-linear elasticity, finite deformationsFL[1], ChS13 ^{16,150} M14Lecture 11Non-linear elasticity, finite deformationsFL[1], ChS13 ^{16,150} M14Lecture 13Non-linear elasticity, finite deformationsFL[1], ChS13 ^{16,150} M14Lecture 14Non-linear elasticity, finite deformationsFL[1], ChS13 ^{16,151} M14Lecture 14Coupled problems: ThermoelasticityFL[1], ChS13 ^{16,150} M14Lecture 14Coupled problems: ThermoelasticityFL[1], ChS13 ^{16,150} M10,MTExerciseFE[1], ChS13 ^{16,150} M14Lecture 14Coupled problems: ThermoelasticityFL[1], ChS13 ^{16,150} M14Lecture 15For analysisFL[1], ChS13 ^{16,150} M14Lecture 16For analysisFL[1], ChS13 ^{16,150} M14Lecture 18For analysisFL[1], ChS13 ^{16,150} M14Lecture 19For analysisFL[1], ChS <td></td> <td>15¹⁵-17⁰⁰</td> <td>MTO, MT9</td> <td>Exercise</td> <td>Hand-out CA2</td> <td>FE</td> <td></td>		15 ¹⁵ -17 ⁰⁰	MTO, MT9	Exercise	Hand-out CA2	FE	
W4 Mon, 25/11 $06^{90}.09^{45}$ Lecture 10 Non-linear elasticity, finite deformations FL [1], Ch5 Wed, 27/11 $10^{90}.11^{45}$ ML14 Lecture 11 Non-linear elasticity, finite deformations FL [1], Ch5 St5 $13^{15}.15^{90}$ ML14 Lecture 12 Non-linear elasticity, finite deformations FL [1], Ch5 W5 Recise Hand-out CA3 FE [1], Ch5 W6d, 2/12 $08^{90}.09^{45}$ ML14 Lecture 13 Non-linear elasticity, finite deformations FL [1], Ch5 W5 St5 $10^{90}.11^{45}$ ML14 Lecture 14 Coupled problems: I hermoelasticity FL [1], Ch5 W6d, 4/12 $00^{90}.11^{45}$ M10, MT9 Exercise FE [1], Ch12 St5's.17^{40} M10 Lecture 15 Error analysis FL [1], Ch15 St5's.17^{40} M10 Lecture 17 Error analysis FL [1], Ch15 St6's.17^{40} MT0, MT9 Exercise FE [1], Ch15 St6's.17^{40} M114 Lecture 17 Error analysis FL	Fri, 22/11	17 ⁰⁰			Hand-in CA1		
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	W4						
	Mon, 25/11	08 ⁰⁰ -09 ⁴⁵	ML14	Lecture 10	Non-linear elasticity, finite deformations	FL	[1], Ch5
		10 ⁰⁰ -11 ⁴⁵	MTO, MT9	Exercise		FΕ	
13 ³³ -15 ⁶⁰ ML14 Lecture 12 Non-linear elasticity, finite deformations FL [1], Ch5 M5 MT0, MT9 Exercise Hand-out CA3 FE I Mon, 2/12 M6 ³⁰ -01 ⁴⁵ ML14 Lecture 13 Non-linear elasticity, finite deformations FL [1], Ch5 M0 ⁶ , 11 ⁴⁵ MT0, MT9 Exercise FE [1], Ch12 M0 ⁶ , 11 ⁴⁵ ML14 Lecture 14 Coupled problems:Thermoelasticity RJ [1], Ch12 M3 ⁵¹ , 17 ⁶⁰ ML14 Lecture 15 Error analysis FL [1], Ch12 M3 ⁵¹ , 17 ⁶⁰ ML14 Lecture 16 Error analysis FL [1], Ch12 M6	Wed, 27/11	10 ⁰⁰ -11 ⁴⁵	ML14	Lecture 11	Non-linear elasticity, finite deformations	FL	[1], Ch5
15 ¹⁵ .17 ⁰⁰ MT0, MT9 Exercise Hand-out CA3 FE W5 10 ⁰⁰ .11 ⁴⁵ ML14 Lecture 13 Non-linear elasticity, finite deformations FL [1], Ch5 M00, 2/12 08 ⁰⁰ .09 ⁴⁵ ML14 Lecture 14 Coupled problems:Thermoelasticity RJ [1], Ch5 Wed, 4/12 10 ⁰⁰ -11 ⁴⁵ ML14 Lecture 15 Error analysis FL [1], Ch15 Fri, 6/12 17 ⁰⁰ MT0, MT9 Exercise Hand-in CA2 III, Ch15 Fri, 6/12 0 ⁰⁰ -11 ⁴⁵ ML14 Lecture 15 Error analysis FL [1], Ch15 M00 9/12 08 ⁰⁰ -09 ⁴⁵ ML14 Lecture 17 Error analysis FL [1], Ch15 10 ⁰⁰ -11 ⁴⁵ MT0, MT9 Exercise Fror analysis FL [1], Ch15 13 ¹⁵¹ -17 ⁰⁰ MT0, MT9 Exercise Fror analysis FL [1], Ch15 13 ¹⁵¹ -17 ¹⁶¹ MT0, MT9 Exercise Fror analysis FL [1], Ch15 13 ¹⁵¹ -17 ¹⁶¹ MT0, MT9 Exercise		$13^{15} - 15^{00}$	ML14	Lecture 12	Non-linear elasticity, finite deformations	FL	[1], Ch5
W5 Mon, 2/12 08 ⁰⁰ -09 ⁴⁵ ML14 Lecture 13 Non-linear elasticity, finite deformations FL [1], Ch5 Wed, 4/12 10 ⁰⁰ -11 ⁴⁵ ML14 Lecture 14 Coupled problems:Thermoelasticity FL [1], Ch12 13 ¹⁵ -15 ⁰⁰ ML14 Lecture 15 Error analysis FL [1], Ch15 15 ¹⁵ -17 ⁰⁰ MT0, MT9 Exercise Hand-in CA2 FE FE W6 FE I1, Ch15 FE [1], Ch15 FE [1], Ch15 M0n 9/12 08 ⁰⁰ -09 ⁴⁵ ML14 Lecture 16 Error analysis FL [1], Ch15 10 ⁰⁰ -11 ⁴⁵ MT0, MT9 Exercise Fe [1], Ch15 10 ⁰⁰ -11 ⁴⁵ MT0, MT9 Exercise FE [1], Ch15 13 ¹⁵ -15 ¹⁰ ML14 Lecture 17 Error analysis FL [1], Ch15 15 ¹⁵ -17 ¹⁰ MT0, MT9 Exercise Fard-out CA4 FE [1], Ch15 15 ¹⁵ -17 ¹⁰ MT0, MT9 Exercise FI [1], Ch15 [1], Ch15 15 ¹⁵ -17 ¹⁰ MT0, MT9 Exercise <		15^{15} -17 ⁰⁰	MTO, MT9	Exercise	Hand-out CA3	FE	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	W5		,				
10 ⁰⁰ -11 ⁴⁵ MT0, MT9 Exercise FE [1], Ch10 Wed, 4/12 10 ⁰⁰ , 11 ⁴⁵ ML14 Lecture 14 Coupled problems:Thermoelasticity RJ [1], Ch12 13 ¹⁵ -15 ⁰⁰ ML14 Lecture 15 Error analysis FL [1], Ch15 ft 17 ⁰⁰ Karcise Hand-in CA2 Karcise FL [1], Ch15 Wed, 11/12 0 ^{80°,} 09 ⁴⁵ ML14 Lecture 16 Error analysis FL [1], Ch15 M00 9/12 0 ^{80°,} 09 ⁴⁵ ML14 Lecture 17 Error analysis FL [1], Ch15 10 ^{0°,} 11 ⁴⁵ MT0, MT9 Exercise Fror analysis FL [1], Ch15 10 ^{0°,} 11 ⁴⁵ ML14 Lecture 17 Error analysis FL [1], Ch15 13 ^{15,} 15 ⁰⁰ ML14 Lecture 18 Error analysis FL [1], Ch15 13 ^{15,150} ML14 Lecture 17 Error analysis FL [1], Ch15 13 ^{15,150} ML14 Lecture 17 Error analysis FL [1], Ch15 13 ^{15,150} ML14 Lecture 20 Course summary - Course review	Mon, 2/12	08 ⁰⁰ -09 ⁴⁵	ML14	Lecture 13	Non-linear elasticity, finite deformations	FL	[1], Ch5
Wed, 4/12 10 ⁰⁰ -11 ⁴⁵ ML14 Lecture 14 Coupled problems:Thermoelasticity RJ [1], Ch12 13 ¹⁵ , 15 ⁰⁰ ML14 Lecture 15 Error analysis FL [1], Ch15 15 ¹⁵ , 17 ⁰⁰ MT0, MT9 Exercise Hand-in CA2 FE W6 70° For analysis FL [1], Ch15 M0n 9/12 08 ⁰⁰ -09 ⁴⁵ ML14 Lecture 16 Error analysis FL [1], Ch15 10 ⁰⁰ , 11 ⁴⁵ MT0, MT9 Exercise FC [1], Ch15 10 ⁰⁰ , 11 ⁴⁵ ML14 Lecture 17 Error analysis FL [1], Ch15 13 ¹⁵ , 15 ⁰⁰ ML14 Lecture 17 Error analysis FL [1], Ch15 13 ¹⁵ , 15 ⁰⁰ ML14 Lecture 18 Error analysis FL [1], Ch15 13 ¹⁵ , 15 ⁰⁰ ML14 Lecture 18 Error analysis FL [1], Ch15 10 ¹⁰ , 11 ⁴⁵ ML14 Lecture 19 Error analysis FL [1], Ch15 10 ¹⁰ , 11 ⁴⁵ ML14 Lecture 10 Course summary - Course review FL, RJ [1], Ch15 10 ¹⁰ ,		10 ⁰⁰ -11 ⁴⁵	MTO, MT9	Exercise		FΕ	[1], Ch10
13 ¹⁵ -15 ⁰⁰ ML14 Lecture 15 Error analysis FL [1], Ch15 15 ¹⁵ -17 ⁰⁰ MT0, MT9 Exercise Hand-in CA2 FE W6 Image: Constraint of the constrai	Wed, 4/12	10 ⁰⁰ -11 ⁴⁵	ML14	Lecture 14	Coupled problems:Thermoelasticity	R J	[1], Ch12
15 ¹⁵ -17 ⁰⁰ MT0, MT9ExerciseFand-in CA2Fri, 6/12FriW6Fri analysisFL[], Ch15M0n 9/12 $08^{00} 0.9^{00}$ M14Lecture 16Fror analysisFL[], Ch15M0n 9/12 $00^{00} .11^{40}$ M10, MT9ExerciseFri analysisFL[], Ch15M00 .11/12 $00^{00} .11^{40}$ M10, MT9ExerciseFror analysisFL[], Ch15M14Lecture 18Error analysisFL[], Ch15M15M10, MT9ExerciseHand-in CA3Week 7FL[], Ch15M0n, 16/12 $08^{00} .09^{40}$ ML14Lecture 19Error analysisM0n, 16/12 $08^{00} .09^{40}$ ML14Lecture 19Error analysisM0n, 16/12 $08^{00} .09^{40}$ ML14Lecture 20Course summary Course reviewFL[], Ch15M14Lecture 20Course summary Course reviewFLFLLecture 19M014Lecture 20Course summary Course reviewFLFL[], Ch15M15M14Lecture 20Course summary Course reviewFLKKM15M14Lecture 20Course summary Course reviewFLKKM15M14		$13^{15} - 15^{00}$	ML14	Lecture 15	E rror analysis	FL	[1], Ch15
Fri, 6/12 17 ⁰⁰ Hand-in CA2 W6		15^{15} -17 ⁰⁰	MTO, MT9	Exercise		FE	
W6 Mon 9/12 08 ⁰⁰ -09 ⁴⁵ ML14 Lecture 16 Error analysis FL [1], Ch15 10 ⁰⁰ -11 ⁴⁵ MT0, MT9 Exercise FE Wed, 11/12 10 ⁰⁰ -11 ⁴⁵ ML14 Lecture 17 Error analysis FL [1], Ch15 13 ¹⁵ -15 ⁰⁰ ML14 Lecture 18 Error analysis FL [1], Ch15 15 ¹⁵ -17 ⁰⁰ MT0, MT9 Exercise Hand-out CA4 FE Fri, 13/12 17 ⁰⁰ MT0, MT9 Exercise Hand-in CA3 Week 7 Mon, 16/12 08 ⁰⁰ -09 ⁴⁵ ML14 Lecture 19 Error analysis FL [1], Ch15 10 ⁰⁰ -11 ⁴⁵ MT0, MT9 Exercise FE FE [1], Ch15 10 ⁰⁰ -11 ⁴⁵ ML14 Lecture 20 Course summary - Course review FL, RJ [1], Ch15 13 ¹⁵ -15 ⁰⁰ ML14 Lecture 20 Course summary - Old exam + Q&A FL, RJ FL 15 ¹⁵ -17 ⁰⁰ MT0, MT9 Exercise FE FE FE Sat, 18/1 (2020) 14 ⁰⁰ -18 ⁰⁰ Written exam FE FE </th <td>Fri, 6/12</td> <td>17⁰⁰</td> <td></td> <td></td> <td>Hand-in CA2</td> <td></td> <td></td>	Fri, 6/12	17 ⁰⁰			Hand-in CA2		
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	Wed, 19/8 (2020)	14 ⁰⁰ -18 ⁰⁰			Re-sit exam		

Literature

[1] M Ekh, R. Jänicke, F. Larsson and K. Runesson, The Finite Element Method – Solid Mechanics. Dept. of Industrial and Materials Science, Chalmers, 2018.

Teachers

RJ = RalfJänicke FL = Fredrik Larsson FE = Fredrik Ekre