Overview: 0

MEK4560
The Finite Element Method in Solid Mechanics II

(January 25, 2008)

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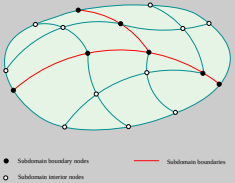

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Content

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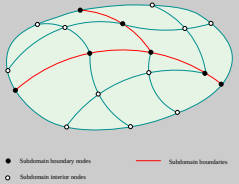

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0. Overview

The finite element method represent one of the greatest achievements in computational mechanics. Today it is the method of choice for structural analysis.

The development of super-tankers in the maritime industry and the development of off-shore installations in the Norwegian continental shelf is based on extensive use of numerical simulations based on the finite element method.

MEK4560, The Finite Element Method in Solid Mechanics II is a continuation of *MEK4550, The Finite Element Method in Solid Mechanics I* with focus on methods for analyzing structures. Some plate and shell models are introduced. Furthermore, dynamic analysis and stability analysis by linearized buckling is considered. Finally, we briefly introduce method for nonlinear analysis. (NOTE: This is tentative!)

The course is developed by Geir Skeie. I will make some minor adjustments, but for the most part the sylabus will be as before. He has also made the LaTeX styles used in the course material. The predecessor of the course was *ME356*, developed by Abdou Bobb and Magne K. Nygård. Some of their material is still in the notes.

Henrik Mathias Eiding will be responsible for the Exercises. He will give an introduction to ANSYS and answer guestions related to the use of ANSYS in the homework assignments. Alternatively, you can use COMSOL for the Exercises.

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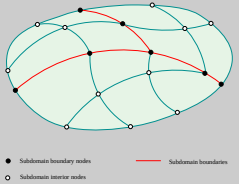
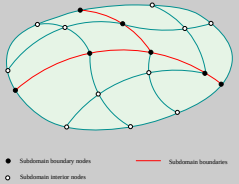


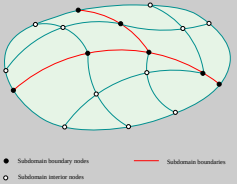
0.1. Course Content

Content	Practical use of the element method as a tool for analysis of different structures. Extending the theoretical basis of the method when it comes to plate and shell structures, dynamic analysis, linearized buckling and plasticity.
Learning outcomes	A thorough introduction to the finite element method applied on typical structural problems. This is achieved through the use of commercial software and lectures that outlines the theoretical basis for the program.
Formal prerequisites	*MEK4550, The Finite Element Method in Solid Mechanics I* or equivalent background in the finite element method.
Recommended prerequisites	*MEK-INF4210, Kontinuumsmekanikk* and *MEK4510, Dynamics of Structures*
Teaching:	$2 + 1$ hours teaching + exercises per week in one semester. Extensive use of computer programs in the exercises.
Exam	Oral.



0.2. General information

Place	Room B 70
Time	Lectures/Exercises: Wednesdays 1615-1800, starting 16. of January/Fridays 1215-1400, starting 25. of January
Exam	Homework + oral exam.
Reading	Cook, Malkus and Plesha [Cook et al., 2002][2], Bell[Bell, 1994][1] and notes.



0.3. Tentative Plan

A tentative plan for the lectures are found in the table below. The column reading refers to the chapters in the textbooks [Cook et al., 2002][2] and [Bell, 1994][1]. C1.1 refer to Cook, Chapter 1.1, similarly for Bell.

Time	Topic	Textbook	Homework	Date
0	Introduction. Computational methods and tools.	C10		16. January
1	Computational methods and tools.	C10	Ø1	23. January
2	Bjelker med skjærtøyninger (Timoshenko bjelke)	Notes, B6.1, B6.7, B6.8, C15.4	Ø2	30. January
3	Variational crimes: Reduced integration, non-compatible modes, the Patch test.	C6.6, C6.13	Ø3	6. February
4	Thin plates	Notes, C15.1, C15.2	Ø4	13. February
5	Thick plates	Notates, C13.4, C15.3, C15.5	Ø5	20. February
6	Platelements	C15.2, C15.3	Ø6	5. march
7	Shell theory	Notes, C16.1, C16.4, C16.5	Ø7	12. march

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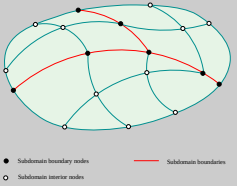

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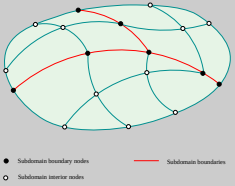
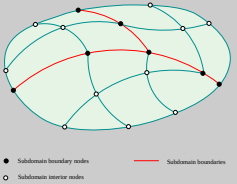
8	Dynamics: Modal analysis	C11.1, C11.2, C11.4, C11.5, C11.7	Ø8	26. march
9	Dynamics: Time integration	C11.11, C11.12, C11.13	Ø9	2. April
10	Second order effects, linearized Buckling	C18.1, C18.2, C18.5, C18.6	Ø10	9. April
11	Full ikke-lineær analyse I	Notater	Ø11	16. april
12	Full ikke-lineær analyse II	Notater	Ø11	23. April
13	Plastisitet	C17.1, C17.3, C17.4, C17.5	Ø12	30. April
14	Adaptivitet	C9.1, C9.2, C9.6, C9.8, C9.9, C9.10, C9.11	Ø13	7. May



0.4. Literature

A list of literature in continuum mechanics, the Finite Element Method and Structural analysis is found in Appendiks 0.5.

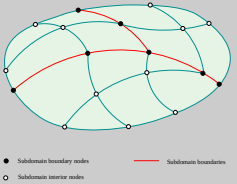


0.5. Syllabus

The following chapters in [Bell, 1994][1].

Chapter		Title	Notes
6		**Special topics**	
	6.1	Skjærdeformasjoner	Lesestoff
	6.7	Romlig bjelkeelement med generelt tverrsnitt	Pensum
	6.8	Det generelle bjelkeelementet	Pensum

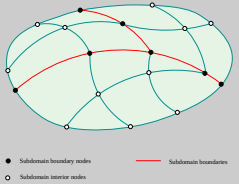
[1] Kolbein Bell. *Matrisestatikk*. Number ISBN: 82-519-1162-1 (ib.). Tapir, 1994.



The following chapters in [Cook et al., 2002][2]

Chapter		Tittle	Notes
6		**Isoparametric elements**	
	6.6	Incompatible modes. Nodeless D.O.F	Pensum
	6.13	Patch test	Pensum
9		**Error, error estimation, and convergence**	
	9.1	Sources of error	Pensum
	9.2	Ill-conditioning	Lesestoff
	9.6	Discretization error. Convergence rate	Pensum
	9.8	Mesh revision methods	Lesestoff
	9.9	Gradient (stress) recovery and smoothing	Pensum
	9.10	A-posteriori error estimate	Pensum
	9.11	Adaptive meshing	Lesestoff
10		**Modeling considerations and software use**	Lesestoff
11		**Finite elements in structural dynamics and vibrations**	Pensum
	11.1	Introduction	Pensum
	11.2	Dynamic equations. Mass and damping matrices.	Pensum

[2] R. D. Cook, D. S. Malkus, M. E. Plesha, and R. J. Witt. *Concepts and Applications of Finite Element Analysis*. Number ISBN: 0-471-35605-0. John Wiley & Sons, Inc., 4th edition, October 2002.



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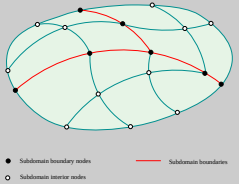

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17		**Nonlinearity: An introduction**	
	17.1	Nonlinear problems	Lesestoff
	17.3	Plasticity: Introduction	Pensum
	17.4	Plasticity: General formulation for small strains	Pensum
	17.5	Plasticity: Formulation for von Mises Theory	Pensum
18		**Stress stiffness and buckling**	
	18.1	Introduction. Energy consideration	Pensum
	18.2	Bar and beam elements	Pensum
	18.5	Calculation of buckling loads	Pensum
	18.6	Remarks on stress stiffness and its use (Form of $[\boldsymbol{k}_\sigma]$. Bounds and errors.)	Lesestoff

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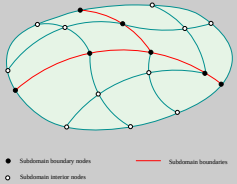

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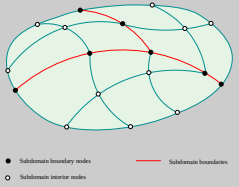

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