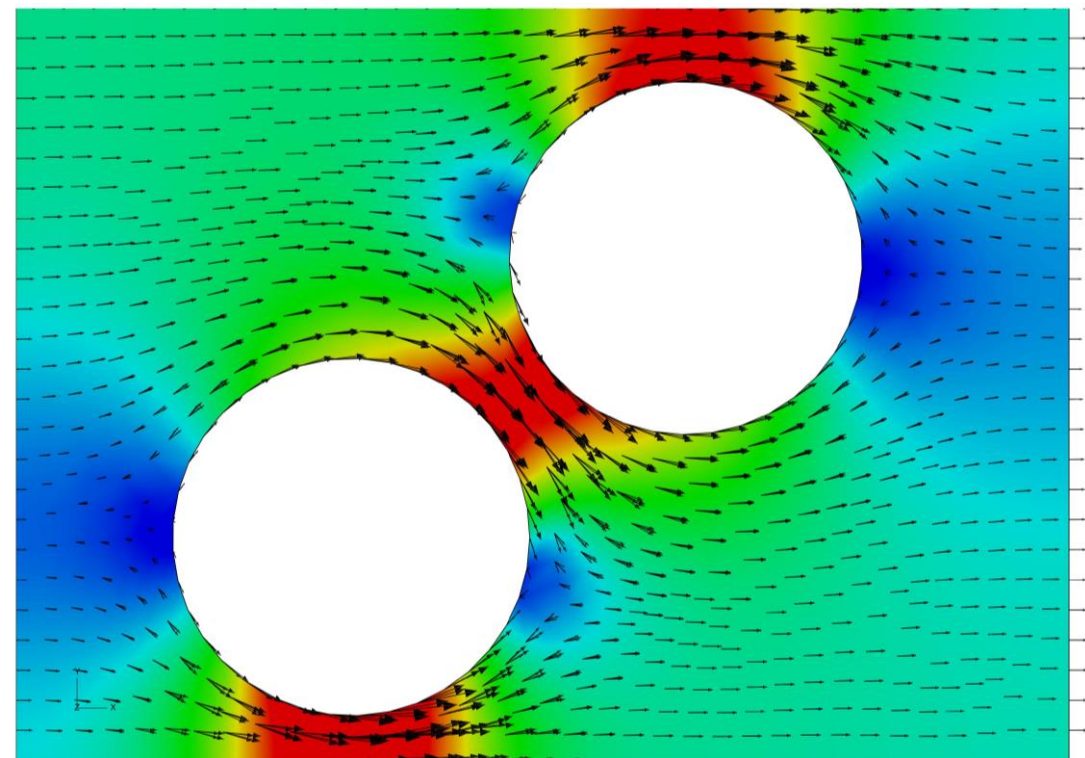# Finite Element Method
- flow problems

VSMN25

Course programme 2016

Finite Element Method – flow problems

The course aims at giving the ability to analyse various types of flow problems by means of the finite element (FE) method. The FE formulation containing: direct approach, strong and weak formulations, approximating functions and weighted residual methods is studied. Focus is on flow problems: heat flow, diffusion and groundwater flow in steady-state and transient conditions. Design assignments are studied to illustrate the procedure of transferring a design problem into a model and to a FE-analysis.

Course Plan

The lectures are held 8.15-10.00 and the problem-solving classes are held 10.15-12 at dates and locations according to the schedule below.

At some exercises, computer labs are booked in either V:Dator11 and V:Dator12 or, V:Dator24 and V:Dator25 according to the schedule below.

Day	Room	Chapter in "*Introduction to the Finite element method*"	Exercise problems
Tue 30/8	A:B V:P1, P2 V:Dator11, 12	1 Introduction 2, 3 Repetition **Presentation of hand-in assignment 1.**	2-1, 2-2, 2-3, 2-4 3-1, 3-2, 3-3, 3-5, 3-8
Fri 2/9	A:B V:R1, S1 V:Dator24, 25	4 Strong and weak formulation 1-dim. heat flow	4-1, 4-2, 4-3, 4-4, 4-5
Tue 6/9	A:B V:P1, P2 V:Dator11, 12	5 Gradient, Gauss theorems, Green-Gauss theorem	5-1, 5-2, 5-3, 5-4, 5-5
Fri 9/9	V:B E:3308, 3315	6 Strong and weak formulation, 2- and 3-dim. heat flow **Hand in of assignment 1 (9/9, 08.15)**	6-1, 6-2, 6-3
Tue 13/9	A:C V:P1, P2	7 Approximating functions	7-1, 7-2, 7-3, 7-4, 7-5,7-6,7-7 7-8, 7-9, 7-11, 7-10, 7-12
Fri 16/9	V:B V:R1, S1	8 Weighted residual methods	8-1
Tue 20/9	KC:C V:P1, P2	9 FEM-formulation, 1-dim. heat flow	9-1, 9-2, 9-3, 9-4, 9-5
Fri 23/9	A:C V:R1, S1 V:Dator24, 25	10 FEM-formulation, 2- and 3-dim. heat flow **Presentation of hand-in assignment 2**	10-1, 10-2, 10-3

Day	Room	Chapter in "*Introduction to the Finite element method*"	Exercise problems
Tue 27/9	MA 6 V:P1, P2 V:Dator11, 12	10 FEM-formulation, 2- and 3-dim. heat flow	10-4, 10-5, 10-6
Fri 30/10	A:B V:R1, S1 V:Dator24, 25	11 Element mesh and node numbering	11-1, 11-2, 11-3, 11-4, 11-5, 11-6, 11-7
Tue 4/10	A:B V:P1, P2 V:Dator11, 12	T Transient heat flow - basic equations, 1-dim - integration in time **Presentation of hand-in assignment 3**	T-1
Fri 7/10	V:C V:N1, N2 V:Dator24, 25	T Transient heat flow - 2- and 3-dim. **Hand in of assignment 2 (7/10, 08.15)**	T-1
Tue 11/10	V:P1, P2 V:Dator11, 12	Time for work with assignment	
Fri 14/10	V:B V:R1, S1	Repetition **Hand in of assignment 3 (14/10, 08.15)**	
Fri 28 /10	Eden:022, 025	Examination 14:00-19:00	

Literature (The books are available at KFS)
- Ottosen, N.S., Petersson, H.: Introduction to the Finite Element Method, Prentice Hall 1992.
- Olsson, K.-G and Heyden, S.: Introduction to the finite element method, Problems, Byggnadsmekanik, Lund 2001.
- *(OPTIONAL)*: CALFEM ver 3.4 - A finite element toolbox to MATLAB, Dep. of Struc. Mech. and Dep. of Solid Mechanics, Lund 2004.
- Handed-out material.

Computer programs

The educational MATLAB toolbox CALFEM will be used continuously during the course. CALFEM will be available in the students' computer laboratory and can be downloaded from the course homepage.

Hand-in assignments

Two compulsory hand-in assignments are included in the course. Groups of 2-3 students work together to solve the assignments and write reports. The first assignment is smaller aiming at introducing the use of CALFEM. The other one is a larger application assignment.

The assignments will be judged and awarded points according to the table below. The points will be accounted for in the final grade:

Assignment 1:   max 2p, minimum 0p
Assignment 2: max 9p, minimum points required for passing 4.5p
Assignment 3: max 9p, minimum points required for passing 4.5p

The assignments must be handed in no later than what is indicated in the course programme. A too late handed in assignment 1 gives 0p and assignment 2 and 3 give 4.5p each when passed.

The following criteria are used for judging the assignments:

Ability to
- state the assumptions made,
- perform calculations,
- summarize and draw conclusions,
- limit to important matters and give a proper and logical account of them.

Examination

In addition with the hand-in assignments, a written examination is given at 28/10-2016, 14.00-19.00 at Eden:022, 025. The maximum number of points and the requirement for passing are:

	Max. points	Requirement for passing
Examination	40p	20p

Grades

For a final grade it is required that the hand-in assignments and the examination are passed. The points achieved for the hand-in assignments and the examination are summed to get a final grade according to the following:

Points	Grade
29 – 39	3
40 – 49	4
50 – 60	5

Allowed means of assistance during examination: Calculator.

Teachers

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This programme together with other course information is available on the web at the homepage of the div. of Structural Mechanics: http://www.byggmek.lth.se/