Continuum Mechanics F4C5008 (12 hp), January-May, 2015

Teacher

Professor Jonas Faleskog, faleskog@kth.se, Phone: 08 - 790 8977.

General

The course is open for PhD-students in Solid Mechanics and related disciplines who are interested in an advanced treatment of continuum mechanics. It should be noted that the course will be organized as a typical course for Ph.D.-students which means that more emphasis is devoted to self studies.

Course content

The course will give a thorough treatment of continuum mechanics for solid materials. Particular emphasis will be given to materials and structures that experince large deformations. Application areas are for example rubber like materials, soft tissue biomaterials and large plastic deformations in metallic materials. More details about the course content are found in the "*Plan for lectures*" below. The lectures will address theoretical issues, which will be illustrated by simple examples. More advanced problems will be solved in the homework assignments.There will also be time for discussion of course topics in general during the lectures whenever it is desired.

Aim of the course

After the course the students should

- be able to correctly apply advanced large deformation theories in modelling of structures and components
- be able to read and understand advanced scientific publications on material models for large deformations
- be confident with tensor analysis both in Cartesian and curvilinear coordinate systems
- be able to apply and evaluate the most common stress, strain and deformation measures
- be able to model rubber like materials, for example soft tissue biomaterials
- be familiar with different approaches for large strain plasticity
- understand finite element implementations for large deformations

Prerequisites

A basic undergraduate course in solid mechanics is required. It is strongly recommended that the course participants also have taken some additional advanced course in solid mechanics such as material mechanics, theory of elasticity, theory of plasticity or continuum mechanics.

Schedule

The time (weeks) for lectures and tutorials are found in the "*Plan for lectures*" below. In total 16 lectures (3x45 min) are give during the course. A detailed schedule (time, dates and lecture halls) can be found on the webpage of the course, see also below.

Literature

The main part of the course is covered by:

Holzapfel, G., *Nonlinear Solid Mechanics, A Continuum Approach for Engineering*, John Wiley & Sons, Ltd, 2000. Paperback: ISBN: 9780471823193.

Brannon, R., *Curviliner Analysis in a Euclidean Space*, Free to download from website http://imechanica.org/node/1551/

The book can be purchased from book stores or from the internet, e.g. www.adlibris.com or www.bokus.com. The price is about 520 SEK. Additional material will also be handed out during the course.

Course homepage:

Course material of interest will be available from the web page

`https://www.kth.se/social/course/SE2140/`

Course requirements

Homework assignments and a written exam. The grades will be pass or fail.

Homework assignments

The course includes five compulsory home work assignments (HW). Satisfactory solutions to these five assignments are required to pass the course. If a student obtain less than 75% of the points on a HW, a complementoray solution must be handed in. Each homework assignment contains different problems to be solved. The deadlines for submission of solutions are indicated in the "*Plan for lectures*" below.

Written examination

The written examination will take place on Friday, May 29, 2015, 08:00–. The written examination is composed of ten problems that each gives a maximum of five points. Hence, completely correct solutions to all problems will give 50 points. It will be required to have at least 25 points in order to pass the course. Students who receive 19 to 24 points on the exam need to carry out an additional examination in order to pass the course. Students who receive 18 points or less, must pass a new written examination. The date for the complementary examination is not yet decided.

Jonas Faleskog
KTH, January 2015

Plan of Lectures

Week, Date	Class	Subject	Literature
4, 20/1–em	L1	Tensor analysis - definitions.	HL:1.1–1.5
5, 27/1–em	L2	Tensor analysis - functions, operators and gradients.	HL:1.7–1.9
6, 2/2–fm	L3	Tensor analysis - general basis and curvilinear coordinates.	HL:1.6 RB
6, 4/2–em	L4	Kinematics - definitions. Deform. gradient.	HL:2.1–2.4
7, 10/2–em **HW1**	L5	Strain and stretch tensors, rotation. Strain tensors in curvilinear coordinates.	HL:2.5–2.6, HO1
8, 17/2–em	L6	Rate of deformation tensors. Lie time derivatives. Definition of stress.	HL:2.7–2.8, 3.1–3.2
9			
10, 4/3–em **HW2**	L7	Stress and traction tensors. Stress tensors in curvilinear coordinates.	HL:3.3–3.4, HO2
11, 10/3–fm	L8	Conservation of mass. Equations of motion.	HL:4.1–4.3
11, 12/3–fm	L9	Thermodynamics.	HL:4.4–4.6
12			
13, 24/3–fm **HW3**	L10	Principle of objectivity.	HL:5.1–5.4

Week, Date	Class	Subject	Literature
13, 26/3–em	L11	Hyperelastic mat. - isotropic rubber like mat.	HL:6.1–6.3
14, 31/3–fm	L12	Mooney-Rivlin, neo-Hookean and Ogden rubber like material models.	HL:6.4–6.6
15			
16, 14/4–fm **HW4**	L13	Anisotropic models.	HL:6.7–6.8
17, 22/4–em	L14	Large strain plasticity.	AN
18, 29/4–em	L15	Variational principles - Linearization	HL:8.1–8.6
19, 5/5–fm	L16	Finite element implementations	Notes & HO3
21, **HW5**			
22	Written examination, 8am–, May 29, 2015		

Time of classes: fm = 8:30 – 11:15 & em = 13:15 – 16:00

Abbreviations: HL:# = Chapters in Holzapfel's book
RB = Book draft by Rebecca Brannon
AN = Paper by A. Needleman, Comp. Struct. **20**, pp. 247-257, 1985.
HO1 = Hand-out material on strain tensors in curvilinear coordinates
HO2 = Hand-out material on stress tensors in curvilinear coordinates
HO3 = Hand-out material on FEM and finite deformations