Course program for Material Mechanics (SE2126), 9 credits

August 2023 – January 2024

Lecturer and examiner
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Teaching assistants
MSc. Vladilena Gaisina, e-mail: gaisina@kth.se, Unit of Solid Mechanics (laboratory work)
MSc. David Lindblom, e-mail: davlindb@kth.se, Unit of Solid Mechanics (tutorials and finite element exercises)

Course goals and learning outcomes
After the course the student should be able to:

- apply three dimensional material models for anisotropic elasticity, non-mechanical strains, plasticity, viscoplasticity, creep, viscoelasticity, damage development in analytic estimates and in finite element calculations.
- judge the practical applicability of the presented material models.
- understand the coupling between micro mechanical modelling and three dimensional material models.
- by use of finite element calculations or in analytic estimates be able to determine the stiffness for laminates, particle composites and materials with micro cracks and materials with periodic microstructure.
- estimate stresses and strain in inclusions.

Literature
- Gudmundson, P., *Material Mechanics*, KTH Solid Mechanics, SEK 250.
- Gudmundson, P., *Material Mechanics: exercises with solutions*, KTH Solid Mechanics, SEK 100.
- Sundström, B., *Handbook of Solid Mechanics*, KTH Solid Mechanics, SEK 350.

The literature is sold at the student office at Teknikringen 8D.

Course requirements

Homework assignments	1.5 credits
Finite element exercises and laboratory work	3.0 credits
Written examination	4.5 credits

All three of these requirements must be fulfilled for passing the course.

Lectures and tutorials
The teaching is divided into lectures by Per-Lennart Larsson and tutorials by David Lindblom. Both lectures and tutorials will be given in the seminar room of the Unit of Solid Mechanics.

It is important that course participants are well prepared before the lectures and tutorials by reading in the book and/or solving problems.

Homework assignments
The course includes two compulsory homework assignments. The assignments should be completed in groups of three course participants and be submitted to the course web no later than October 27 for homework 1 and November 24 for homework 2. The students should sign up for a group on the Canvas page for the course. The groups should be the same for both homeworks. Each homework assignment is composed of three problems that each has a maximum of 6 points. The number of points required to pass a homework is 11. Satisfactory solutions to the two homework assignments will give 1,5 credits. The

solutions to the homeworks will be distributed on Canvas.

Finite element exercises and laboratory exercise
The course includes four finite element exercises and one laboratory experiment. Satisfactory solutions to the finite element exercises, participation in the laboratory experiment, and a satisfactory lab-report together give 3.0 credits.

The finite element exercises and the laboratory exercise should be completed in groups of three course participants (same groups as for the homework assignments). The groups should remain the same for all exercises.

The finite element software package COMSOL Multiphysics will be used as a tool for the finite element exercises. This software is available to all students. **It is very important that the students install COMSOL on their own computers prior to the first finite element exercise.** The results will be presented and discussed in the Solid Mechanics track room (or possibly another meeting room) with the teaching assistant. A 15 minute time slot is reserved for each group and finite element exercise. Each group should sign up for a time slot by contacting David Lindblom (davlindb@kth.se). The following time slots are available:

Schedule for 15 minutes presentations of finite element exercises

	Date	**Time**
1. Anisotropic elasticity	September 6	13-15, eight 15 minute time slots
	September 7	13-15, eight 15 minute time slots
2. Plasticity	October 11	13-15, eight 15 minute time slots
	October 12	13-15, eight 15 minute time slots
3. Viscoelasticity	November 15	13-15, eight 15 minute time slots
	November 16	13-15, eight 15 minute time slots
4. Micro mechanics	December 13	13-15, eight 15 minute time slots
	December 14	13-15, eight 15 minute time slots

The laboratory exercise will be conducted in the Solid Mechanics laboratory. The lab-report should be completed in the groups of three course participants, deadline December 15, and submitted to Vladilena Gaisina (gaisina@kth.se). Instructions for the laboratory work are found on the course web site. It is mandatory to read the instructions and to solve the preparatory problems before the laboratory exercise starts. The student groups should sign up for a time slot by contacting Vladilena Gaisina (gaisina@kth.se). The following time slots are available:

Schedule for laboratory exercise (Solid Mechanics laboratory)

	Date	**Time**
Laboratory exercise	December 4	8-10, 10-12
	December 5	8-10, 10-12
	December 6	13-15, 15-17
	December 7	13-15, 15-17

Final written examination
The written examination will take place on January 8, at 8-13. The student must register his/her participation in advance. Allowed aids on the exam are *Material Mechanics* (textbook only), *Handbook of Solid Mechanics*, mathematical handbooks, and pocket calculator. Lecture notes, copied material, computers or mobile phones are *not* allowed on the exam.

The written examination is composed of six problems that each has a maximum of six points. Hence, completely correct solutions to all problems will give 36 points. At the grading of a problem, reduction is made with: 1 point for a careless mistake or a small computational error, 2 points for a smaller principal error and 6 points for a serious principal error. If the point reductions are larger than 3, the grading will be 0 points for that particular problem.

The total points on the exam are used to assign grades on the whole course, accordingly:

- 0-11 points F
- 12-13 points FX
- 14-17 points E
- 18-21 points D
- 22-25 points C
- 26-28 points B
- 29-36 points A

For those who get 12-13 points at the written examination it will be possible to make a complementary exam. A successful outcome of this examination will give the Grade E. The complementary examination consists of two new problems that cover two specified subject areas and that each has a maximum of six points. To achieve the Grade E at least seven points are required. The principles for corrections will be the same as in the ordinary examination. The complementary examination will take place approximately two weeks after the written examination has been corrected and the results published. Details regarding time, place and subject areas will be announced on the course web at the same time. Those who are qualified and interested in a complementary examination should notify Per-Lennart Larsson at the latest one week before the announced date for the complementary exam.

Lectures and tutorials are held in the seminar room of the Unit of Solid Mechanics.

Date, Time	Subject	Reading	Problems
Aug 28, 10-12	Introduction. Continuum mechanics, energy relations, FEM 1.5, 2.7	Ch. 1-4	1.1-7, 2.1-7
Aug 30, 15-17	Anisotropic elasticity 5.5	Ch. 5	5.1-13
Aug 31, 15-17	Tutorial 1.1, 2.1, 5.8, 5.11, 5.13		
Sep 4, 10-12	Inelastic strains, plasticity of metals 6.1	Ch. 6	6.1-2
Sep 5, 8-10	Plastic yield criteria 7.1	Ch. 7	7.1-7
Sep 11, 10-12	Tutorial 6.2, 7.2, 7.6, 7.7		
Sep 12, 8-10	Plastic deformation 8.1	Ch. 8.1-8.4	8.1-9
Sep 18, 10-12	Plastic deformation, continued		8.1-9
Sep 19, 8-10	FEM – plastic deformation	Ch. 8.6	
Sep 25, 10-12	Tutorial 8.4, 8.8, 8.9		
Sep 26, 8-10	Creep and viscoplasticity 9.2	Ch. 9.1-4	9.1-5
Oct 2, 10-12	FEM - creep and viscoplasticity	Ch. 9.5	
Oct 3, 8-10	Viscoelasticity 10.1	Ch. 10.1-4	10.1-6
Oct 9, 10-12	Viscoelasticity, continued	Ch. 10.5-6	10.1-6
Oct 27	Deadline homework assignment 1		
Oct 30, 10-12	Tutorial 9.1, 9.3, 10.2, 10.3		
Okt 31, 8-10	Repetition of the first part of the course	Ch. 1-10	
Nov 6, 10-12	Damage mechanics 11.1	Ch. 11	11.1-6
Nov 7, 8-10	Damage mechanics, continued		11.1- 6
Nov 13, 10-12	Laminate theory 12.1	Ch. 12	12.1-3
Nov 14, 8-10	Tutorial 11.2, 11.4, 11.6, 12.2, 12.3		
Nov 20, 10-12	Micro mechanics, averages 13.1	Ch. 13.1-3	13.1
Nov 21, 8-10	Micro mechanics, effective properties 13.2	Ch. 13.4	13.1-4, 13.6-13
Nov 24	Deadline homework assignment 2		
Nov 27, 10-12	Tutorial 13.3, 13.6, 13.8, 13.12		
Nov 28, 8-10	Micro mechanics, bounds 13.5	Ch. 13.5	13.5
Dec 11, 10-12	Repetition	Ch. 11-13	
Dec 12, 8-10	Tutorial Old exam		

Chapters and paragraphs refer to the *Materials Mechanics* book. Problems refer to the book: *Material Mechanics: exercises with solutions*