Course program for Material Mechanics (SE2126), 9 credits

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Lecturer and examiner
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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 Peter Gudmundson and tutorials by Hossein Shariati. Both lectures and tutorials will be given online through zoom sessions. Links to zoom are provided on the Canvas page for the course. The lectures include theory mixed with example problems. The tutorials are focused on problem solving.

Quizzes
Quizzes are prepared for each lecture. The students are expected to read the appropriate pages in the Material Mechanics book before each lecture. The quizzes are a help to check the understanding of the lecture contents.

The quizzes are anonymous and are supposed to be a help for the individual learning. The correct answers and comments to the answers will be shown after the answers have been submitted.

Homework assignments
The course includes two compulsory homework assignments. The assignments should be completed individually and submitted to the course web no later than October 7 for homework 1 and November 29 for homework 2. 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 discussed at two seminars. See the detailed course plan for dates of these two seminars.

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. The students should sign up for a group on the Canvas page for the course. The groups remain the same for all exercises.

The finite element software package ANSYS will be used as a tool for the finite element exercises. This software is available to all students. The results will be presented and discussed online with the teaching assistant. A 40 minute time slot is reserved for each group and finite element exercise. Zoom-links to the different sesssions are provided on the Canvas page for the course. Each group should sign up for a time slot in the Canvas Calendar. The following time slots are available:

Schedule for 40 minutes online presentations of finite element exercises

	Date	**Time**
1. Anisotropic elasticity	September 1	13-17, six 40 minute time slots
	September 2	13-17, six 40 minute time slots
2. Plasticity	October 6	13-17, six 40 minute time slots
	October 7	13-17, six 40 minute time slots
3. Viscoelasticity	November 5	13-17, six 40 minute time slots
	November 6	13-17, six 40 minute time slots
4. Micro mechanics	November 27	13-17, six 40 minute time slots
	November 30	13-17, six 40 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. 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 on the Canvas page for the course. The following time slots are available:

Schedule for laboratory exercise (Solid Mechanics laboratory)

	Date	**Time**	
Laboratory exercise	December 2	8-12	13-17
	December 3		13-17
	December 4		13-17

Final written examination
The written examination will take place on January 7, at 8-13. Depending on the development of the Corona virus it is not yet decided if will be a traditional exam in lecture halls or an internet based exam. 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 Peter Gudmundson at the latest one week before the announced date for the complementary exam.

Detailed plan for internet based lectures, tutorials and seminars

Date, Time	Subject	Reading	Problems
Aug 24, 10-12	Introduction. Continuum mechanics 1.5, 2.7	Ch. 1-3	1.1-7, 2.1-7
Aug 25, 8-10	Energy relations, FEM	Ch. 4	
Aug 26, 15-17	Anisotropic elasticity 5.5	Ch. 5	5.1-13
Aug 27, 15-17	Tutorial 1.1, 2.1, 5.8, 5.11, 5.13, other examples		
Aug 31, 10-12	Inelastic strains, plasticity of metals 6.1	Ch. 6	6.1-2
Sep 1, 8-10	Plastic yield criteria 7.1	Ch. 7	7.1-7
Sep 7, 10-12	Tutorial 6.2, 7.2, 7.6, 7.7, other examples		
Sep 8, 8-10	Plastic deformation 8.1	Ch. 8.1-8.4	8.1-9
Sep 14, 10-12	Plastic deformation, continued		8.1-9
Sep 15, 8-10	FEM – plastic deformation	Ch. 8.6	
Sep 21, 10-12	Tutorial 8.4, 8.8, 8.9, other examples		
Sep 24, 15-17	Creep and viscoplasticity 9.2	Ch. 9.1-4	9.1-5
Sep 28, 10-12	FEM - creep and viscoplasticity	Ch. 9.5	
Sep 29, 8-10	Viscoelasticity 10.1	Ch. 10.1-4	10.1-6
Okt 5, 10-12	Viscoelasticity, continued	Ch. 10.5-6	10.1-6
Oct 7	Deadline homework assignment 1		
Oct 8, 15-17	Tutorial 9.1, 9.3, 10.2, 10.3, other examples		
Oct 9, 10-12	Homework assignment seminar 1 Tutorial		
Nov 2, 10-12	Repetition of the first part of the course	Ch. 1-10	
Nov 3, 8-10	Damage mechanics 11.1	Ch. 11	11.1-6
Nov 9, 10-12	Damage mechanics, continued		11.1- 6
Nov 10, 8-10	Laminate theory 12.1	Ch. 12	12.1-3
Nov 16, 10-12	Tutorial 11.2, 11.4, 11.6, 12.2, 12.3, other examples		
Nov 23, 10-12	Micro mechanics, averages 13.1	Ch. 13.1-3	13.1
Nov 24, 8-10	Micro mechanics, effective properties 13.2	Ch. 13.4	13.1-4, 13.6-13
Nov 26, 15-17	Micro mechanics, bounds 13.5	Ch. 13.5	13.5
Nov 29	Deadline homework assignment 2		
Nov 30, 10-12	Tutorial 13.3, 13.6, 13.8, 13.12, other examples		
Dec 1, 8-10	Homework assignment seminar 2 Tutorial		
Dec 7, 10-12	Tutorial Old exam		
Dec 8, 8-10	Repetition	Ch. 1-13	

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