# Course program for Material Mechanics (SE2126), 9 credits

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**Lecturer and examiner**
Professor Peter Gudmundson, e-mail: petergu@kth.se, phone: 08-790 7556, Department of Solid Mechanics

**Teaching assistant**
MSc. Hossein Shariati, e-mail: hsha@kth.se, Department of Solid Mechanics

**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 80.
- Sundström, B., *Handbook of Solid Mechanics*, KTH Solid Mechanics, SEK 250.

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.

**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. It is recommended to do the quizzes before and after the lectures.

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.

Statistics of the student answers will be compiled. If there are questions that seem to be poorly understood they will be brought up at the next lecture.

**Homework assignments and peer assessment seminars**
The course includes two compulsory homework assignments. The assignments should be completed individually and submitted to the course web no later than October 9 for homework 1 and November 20 for homework 2. The homeworks will be discussed at two seminars where the students will receive an outline of the correct solution to the assignment, and are required to correct another student's assignment. Satisfactory solutions to the homework assignments and satisfactory corrections of other students´ assignments will give 1,5 credits. 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 should be completed in groups of three course participants. The students should sign up for a group on the course web site. The finite element software package ANSYS will be used as a tool. This software is available to all students. Following the instructions from the course web, the groups should solve the different tasks. The results will then for each group be presented and discussed with a teaching assistant. A one hour slot is reserved for each group and finite element exercise. Two groups will be examined in parallel. Each group should sign up for a time slot on the course web site. The following time slots are available:

*Schedule for presentation of finite element exercises (Solid Mechanics track room)*

| | **Date** | **Time** | | | |
|---|---|---|---|---|---|
| 1. Anisotropic elasticity | September 12 | 13-14 | 14-15 | 15-16 | 16-17 |
| | September 13 | 13-14 | 14-15 | 15-16 | 16-17 |
| 2. Plasticity | October 3 | 13-14 | 14-15 | 15-16 | 16-17 |
| | October 4 | 13-14 | 14-15 | 15-16 | 16-17 |
| 3. Viscoelasticity | October 31 | 13-14 | 14-15 | 15-16 | 16-17 |
| | November 1 | 13-14 | 14-15 | 15-16 | 16-17 |
| 4. Micro mechanics | November 28 | 13-14 | 14-15 | 15-16 | 16-17 |
| | November 29 | 13-14 | 14-15 | 15-16 | 16-17 |

The laboratory exercise will be conducted in the Solid Mechanics laboratory. The lab-report should be completed in 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 one out of four laboratory exercise occasions. The following time slots are available:

*Schedule for laboratory exercise (Solid Mechanics laboratory)*

| | **Date** | **Time** | |
|---|---|---|---|
| Laboratory exercise | December 10 | 8-12 | |
| | December 13 | | 13-17 |
| | December 14 | 8-12 | 13-17 |

**Final written examination**
The written examination will take place on January 8, at 8-13 in E1. 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 lectures, tutorials and seminars**

| Date, Time | Room | Subject | Reading | Problems |
|---|---|---|---|---|
| Aug 27, 10-12 | Solid Mech. | Introduction. Continuum mechanics<br>1.5, 2.7 | Ch. 1-3 | 1.1-7,<br>2.1-7 |
| Aug 28, 8-10 | Solid Mech. | Energy relations, FEM | Ch. 4 | |
| Aug 29, 15-17 | Solid Mech. | Anisotropic elasticity<br>5.5 | Ch. 5 | 5.1-13 |
| Sep 3, 10-12 | Solid Mech. | Tutorial<br>1.1, 2.1, 5.8, 5.11, 5.13, other examples | | |
| Sep 4, 8-10 | Solid Mech. | Inelastic strains, plasticity of metals<br>6.1 | Ch. 6 | 6.1-2 |
| Sep 6, 15-17 | Solid Mech. | Plastic yield criteria<br>7.1 | Ch. 7 | 7.1-7 |
| Sep 17, 10-12 | Solid Mech. | Tutorial<br>6.2, 7.2, 7.6, 7.7, other examples | | |
| Sep 18, 8-10 | Solid Mech. | Plastic deformation<br>8.1 | Ch. 8.1-8.4 | 8.1-9 |
| Sep 19, 15-17 | Solid Mech. | Plastic deformation, continued | | 8.1-9 |
| Sep 21, 10-12 | Solid Mech. | FEM – plastic deformation | Ch. 8.6 | |
| Sep 24, 10-12 | Solid Mech. | Tutorial<br>8.4, 8.8, 8.9, other examples | | |
| Sep 26, 15-17 | Solid Mech. | Creep and viscoplasticity<br>9.2 | Ch. 9.1-4 | 9.1-5 |
| Sep 27, 15-17 | Solid Mech. | FEM - creep and viscoplasticity | Ch. 9.5 | |
| Oct 1, 10-12 | Solid Mech. | Viscoelasticity<br>10.1 | Ch. 10.1-4 | 10.1-6 |
| Oct 2, 8-10 | Solid Mech. | Viscoelasticity, continued | Ch. 10.5-6 | 10.1-6 |
| Oct 9 | | Deadline homework assignment 1 | | |
| Oct 10, 15-17 | Solid Mech. | Tutorial<br>9.1, 9.3, 10.2, 10.3, other examples | | |
| Oct 11, 15-17 | Solid Mech. | Homework assignment seminar 1<br>Tutorial | | |
| Nov 5, 10-12 | Solid Mech. | Repetition of the first part of the course | Ch. 1-10 | |
| Nov 6, 8-10 | Solid Mech. | Damage mechanics<br>11.1 | Ch. 11 | 11.1-6 |
| Nov 12, 10-12 | Solid Mech. | Damage mechanics, continued | | 11.1- 6 |
| Nov 13, 8-10 | Solid Mech. | Laminate theory<br>12.1 | Ch. 12 | 12.1-3 |
| Nov 14, 15-17 | Solid Mech. | Tutorial<br>11.2, 11.4, 11.6, 12.2, 12.3, other examples | | |
| Nov 15, 15-17 | Solid Mech. | Micro mechanics, averages<br>13.1 | Ch. 13.1-3 | 13.1 |
| Nov 19, 10-12 | Solid Mech. | Micro mechanics, effective properties<br>13.2 | Ch. 13.4 | 13.1 -4,<br>13.6-13 |
| Nov 20, 8-10 | Solid Mech. | Micro mechanics, bounds<br>13.5 | Ch. 13.5 | 13.5 |
| Nov 20 | | Deadline homework assignment 2 | | |
| Nov 21, 15-17 | Solid Mech. | Tutorial<br>13.3, 13.6, 13.8, 13.12, other examples | | |
| Nov 22, 15-17 | Solid Mech. | Homework assignment seminar 2<br>Tutorial | | |
| Dec 3, 10-12 | Solid Mech. | Tutorial<br>Old exam | | |
| Dec 5, 15-17 | Solid Mech. | Repetition | Ch. 1-13 | |

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