Applied Elasticity with FEM (SE2132) 9 credits, fall 2020

Structure

The course gives the foundation for two- and three dimensional theory of elasticity with applications to plates, shells and contact problems. The finite element method (FEM) is used throughout the course for analysis of more complicated problems of practical interest.

Content

Two dimensional theory of elasticity, theory of plates and shells, buckling of plates, non-linear elasticity, two- and three dimensional contact mechanics, FEM for two- and three dimensional problems, FEM of plates and shells, FEM in contact mechanics.

Teachers

The teaching consists of lectures, tutorials and laboratory works. Details are shown on p. 4. The laboratories will be carried out in *Spårrum Hållfasthetslära* (except the extra laboratory work).

Lectures

Per-Lennart Larsson (coordinator), email: plla@kth.se, phone: 790 7540

Tutorials and Laboratory works

Christopher Miller, email: chrismi@kth.se

Schedule

Time and place for the lectures, lessons, tutorials and laboratory works are found on the KTH webpage (www.kth.se) and the content is detailed on p. 4. **Please note that there might be changes in the schedule due to the Coronasituation.**

Suggested Course literature

- *P.-L. Larsson & B. Storåkers*, Exempelsamling i elasticitetsteori (EX), 100 SEK.
- *B. Sundström*, Formelsamling i hållfasthetslära/Handbook of Solid Mechanics (FS), 250 SEK.
- *"Course map"* containing copied material, 100 SEK.

Literature is sold at the Student Office TR8, Teknikringen 8D, room: 6251; time: 12 – 15; phone: 08 –790 91 97.

Course requirements

Laboratory work (LAB1; 1.5p)

The course includes six scheduled (see detailed program on p. 4) computer laboratory works. Four of the laboratory works are compulsory; related material will be handed out prior each laboratory. The laboratory works are carried out in *Spårrum Hållfasthetslära* (except the extra laboratory work) in groups of, at least, two students. Before each of the laboratory works input-files to the FEM-program ANSYS will be distributed to the students via email. When all four compulsory laboratory works are approved, each student in the group is awarded 1.5 credits.

Details of the laboratory works

1. Introduction to ANSYS: Some simple examples are solved in order to make the students familiar with the FEM-program ANSYS.
2. Compulsory laboratory work 1: Flat plate with a central circular hole is loaded in uniaxial tension. In particular, effects from the outer boundaries are studied.
3. Compulsory laboratory work 2: Bending of a rectangular plate. Comparison between three dimensional FEM solutions and FEM solutions based on standard plate theory.
4. Compulsory laboratory work 3: Buckling of a quadratic plate with a central circular hole loaded in biaxial tension. When does buckling occur?
5. Compulsory laboratory work 4: Indentation of a rigid sphere into an elastic half-space. Investigate the accuracy of the numerical solution.
6. Extra laboratory time: Additional time intended for groups that have not been approved on one (or more) of the mandatory laboratory works listed above. Contact Christopher Miller for details.

Project (PRO1; 3p)

When approaching the end of the course a compulsory project task will be handed out and carried through by the groups from the laboratory works. When the project is finalized and the (short) final report is approved, each student in the group is awarded 3 credits. Some further information about the projects is given in the document “Information about the projects in Applied Elasticity with FEM (SE2132)”.

Written examination (TEN1; 4.5p)

A written examination will take place January 15. **Please note that this might change due to the Coronasituation.** The student must register his/her participation in the exam at least two weeks ahead. The date for the re-exam will be announced later. The written examination is composed of six problems that each has a maximum of six points. Five problems are calculation examples and one problem is composed of theory questions. 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. At the examination it is allowed to use

- Formelsamling I hållfasthetslära/Handbook of Solid Mechanics
- Introduction to contact mechanics and non-linear elasticity as it is provided through the course map
- mathematical handbooks
- pocket calculator.

The grading will be made according to:

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

The grade achieved by a student on the written examination is also his/her final grade on the course. For students who get 12-13 points at the written examination, it will be possible to make a complementary examination. A successful outcome of this examination will give the grade E. The date for the complementary examination will be set-up together with the candidates. Those who are qualified and interested in a complementary examination should notify the lecturer at the latest one month after the written exam. The complementary examination will consist 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. Some further information about the exam is given in the document “Structure of the exam in Applied Elasticity with FEM (SE2132)”.

Course evaluation

All students are asked to participate in a course evaluation at the end of the course.

Detailed program

The course program is listed below. F denotes lectures, T denotes tutorials, and Lab denotes laboratory works. **Please note that there might be changes in the schedule due to the Coronasituation.** In the "course map", the copied material pertinent to a particular lecture is indicated. If not otherwise stated, the numbering of the examples refer to EX.

Details	Subject
Week 35	
F1/ Wed 26 aug 10-12	Repetition: Basic continuum mechanics
F2/ Thu 27 aug 10-12	Repetition: FEM
Week 36	
F3/ Mon 31 aug 13-15	2D elasticity ("skivor")
T1/ Wed 2 sep 10-12	2D elasticity ("skivor"); example: 1.1, 1.4, 1.6, 1.9
Lab0/ Thu 3 sep 10-12	Introduction to ANSYS
Lab0/ Fri 4 sep 10-12	Introduction to ANSYS
Week 37	
F4/ Wed 9 sep 10-12	2D elasticity ("skivor"), contd/Thin plates
T2/ Thu 10 sep 10-12	2D elasticity ("skivor"); example: 1.23, 1.27, 1.29, old exam
F5/ Fri 11 sep 10-12	Thin plates, contd
Week 38	
F6/ Thu 17 sep 10-12	Thick plates
T3/ Fri 18 sep 10-12	Thin and thick plates; example: 2.3, 2.4, 2.6, 2.8
Week 39	
Lab1/ Wed 23 sep 10-12	Compulsory laboratory work 1
Lab1/ Thu 24 sep 10-12	Compulsory laboratory work 1
T4/ Fri 25 sep 10-12	Thin and thick plates; example: 2.7, 2.9, old exam
Week 40	
F7/ Wed 30 sep 10-12	Thin shells
F8/ Thu 1 oct 10-12	FEM for plates and shells
Week 41	
T5/ Wed 7 oct 10-12	Shell theory; example: 3.13, 3.15, old exam
F9/ Thu 8 oct 10-12	Buckling of thin plates
Week 44	
F10/ Tue 27 oct 10-12	Finite elasticity
T6/ Thu 29 oct 8-10	Buckling of thin plates; example: 2.21, 2.22, old exam
Week 45	
Lab2/ Tue 3 nov 10-12	Compulsory laboratory work 2
Lab2/ Wed 4 nov 10-12	Compulsory laboratory work 2
F11/ Thu 5 nov 8-10	2D contact mechanics
Week 46	
T7/ Tue 10 nov 10-12	Finite elasticity; example: 5.2, 5.3, old exam
Lab3/ Wed 11 nov 10-12	Compulsory laboratory work 3
Lab3/ Thu 12 nov 8-10	Compulsory laboratory work 3
Week 47	
F12/ Thu 19 nov 8-10	3D contact mechanics
T8/ Fri 20 nov 15-17	2D contact mechanics; example: 4.4, 4.8, old exam
Week 48	
F13/ Tue 24 nov 10-12	3D contact mechanics, contd
F14/ Thu 26 nov 8-10	3D contact mechanics, contd/FEM in contact mechanics
Week 49	
T9/ Tue 1 dec 10-12	3D contact mechanics; example 4.18, 4.22, old exam
Lab4/ Tue 1 dec 13-15	Compulsory laboratory work 4
Lab4/ Tue 1 dec 15-17	Compulsory laboratory work 4
F15/ Thu 3 dec 10-12	Projects. Closure.
Week 50	
Labe/ Fri 11 dec 15-17	Extra laboratory time if required
Week 2	
Exam/ Fri 15 jan 08-13	