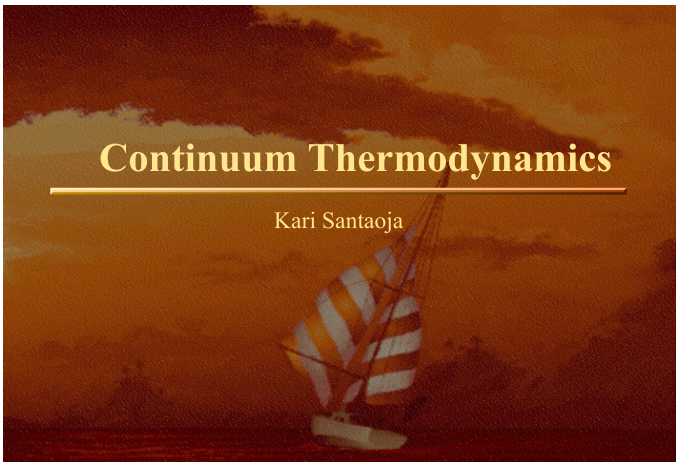
MEC-E8002 Continuum mechanics and material modelling (5,0 cr) 2022

February 13, 2022

What to read for examination

This document gives some hints and instructions concerning what to read for the examination on the present course.

The problems in the examination have the same style as the homework and what was presented during the lectures. The following list gives more detailed instructions what to read in individual chapters and sections of the *Lecture notes on continuum thermodynamics*. At the end of the list the important parts of the lecture notes on the *Extended Levenberg-Marquardt method for Determination of Values for Material Parameters* are highlighted.



Chapter 1; Have a brief look. Skip Section 1.2.

Chapter 2; Three part os of this chapter are given to students in the examination. These parts include the following pages: 33-54, 59-64 and 68. So the “missing” pages contain good candidates for the problems in the examination. Be sure that you understand the content of Chapter 2 and that you do not have time to study Chapter 2 during the examination.

Chapter 3; Read Sections 3.1, 3.2, 3.3 and 3.5, but skip Examples 3.1, 3.2, 3.3 and 3.5. Skip Section 3.4. Study Section 3.5 to the beginning of the last paragraph on page 100. Read the end of Section 3.5 starting from the word “, thus, the velocity” above Equation (109). Read Sections 3.6.and 3.7. In Section 3.8 read only Equations (3.126), (3.127), (3.155) and (3.157). Skip Section 3.9, except page 115. At this point, study Figure 5.12 on page 194. It hopefully gives a helpful view of the content of Chapter 3.

Chapter 4; Read Sections 4.1- 4.7 with the following exception. In Section 4.3 read only Equations (4.17), (4.18) and (4.23).Section 4.6 starting above Equation (4.41) is very important. Skip Sections 4.8, 4.9, 4.10 and 4.11. In Section 4.12 read page 144. In Section 4.13 read the paragraph around Equation (4.90) and study Figure 4.12(a). Skip Sections 4.14 and 4.15. Read carefully Section 4.16 so that you can derive Result (4.126). Skip Section 4.17. In Section 4.18 read the first page except two last lines and page 152 and Equations (4.156)...(4.159). Be sure that you can derive Results (4.125) and (4.126) and you can give correct explanation for every step within the derivation. Please, notice that the end of Section 4.6 starting above Equation (4.41) is a vital part of the explanation.

Chapter 5; Read the first page and last paragraph of Section 5.1 and be aware of the message of Section 5.1. It is Newton’s laws are not required for the beam theory. Skip Sections 5.2, 5.3 and 5.4. Read Sections 5.5 and 5.6. I would like to get your opinion on Section 5.5. Is it clear enough?

Chapter 6; Have a brief look at Section 6.1. Sections 6.2 and 6.3 are important. You have to be capable to derive results given in Examples 6.1, 6.2 and 6.3.

Chapter 7; Be sure that you are aware of the messages on pages 213-217. Skip Section 7.1. Have a brief look at Section 7.2.

Chapter 8; Study the beginning of Chapter 8. Read the end of Section 8.1 from Equation (8.36). Study to understand the quantities of Energy Equation [i.e. local form of the first law of thermodynamics] (8.37) [and (8.38)]. Skip Sections 8.2, 8.3 and 8.4.

Chapter 9; Study the text before Section 9.1. Study the end of Section 9.1 starting from Equation (9.21). Study to understand the quantities in the local form of the second law of thermodynamics [i.e. Inequality (9.21)]. Skip Sections 9.2 and 9.3.

Chapter 10; Look at pages 249-253 briefly. The italicised text at the bottom of page 249, Expression (10.4) and Figure 2 on page 253 are important. Skip Section 10.3. You must be able to explain the reason for the existence of the difference $\boldsymbol{\varepsilon} - \boldsymbol{\varepsilon}^{\mathrm{i}}$ in Equation (10.16) and for the reason material models are written in terms of the specific Helmholtz free energy ψ instead of the specific internal energy u. You have to remember State Equations (10.19), (10.20), (10.22), (10.26), (10.28), (10.34) and (11.35) and you must be capable of extending these state equation for a new set of state variables, as is done in Equations (10.30), (10.31), (10.37) and (10.38). The method for replacing the specific internal energy u by the specific Helmholtz free energy ψ belongs here. The same holds for the relation between the specific Helmholtz free energy ψ and the specific Gibbs free energy g. A verbal explanation is enough and you need not be able to give a detailed derivation. Skip Section 10.5.

Chapter 11; The idea expressed before Section 11.1. You must be able to derive (11.10) and (11.13) and to know how to apply Equation (11.10).

Chapter 12; You need to be able to derive Expression (12.11) and Clausius-Duhem Inequality (12.12) from the given local form of the first law of thermodynamics, Expression (12.1), and of the local form of the second law of thermodynamics, Expression (12.2). Be sure that you can derive Rate (12.9) [You can apply Equation (2.172) which is in the material you have in the examination)]. You must be able to write Separations (12.13) and (12.14). You need to know how to extend these equations for a new set of variables [cf. Homework 5 or Expression (12.15)]. Skip Section 12.2.

Chapter 13; Study the following topics: Read the beginning of the chapter up to Equation (13.7) [not included]. You must be able to write Normality Rule (13.20), (13.21), (13.24), (13.25) and (13.27) as well as to extend them for a new material model. The same holds for Conditions (13.22) and (13.28).

Chapter 14; Read up to the middle of page 284, to the paragraph starting “The dissipative part of the material model ...”. Study to derive Result (14.8). You have to remember that the result of Chapter 14 given in the title of Chapter 14 holds for separated dissipation potentials as well.

Chapter 15; Skip.

Chapter 16; Skip.

Chapter 17; Skip.

Chapter 18; Read carefully. This chapter is important. Since the numbered steps starting from page 314 are hard to read, you may study Section 8.1 and when reading a certain step you can study that particular step in the beginning of Chapter 18.

Chapter 19; Read from the beginning to Figure 19.1.

Chapter 20; Skip Sections 20.2, 20.3, 20.5 and 20.6.

Chapter 21; Only Section 21.1.4 “Strain property...”.

Chapter 22; Read the whole chapter excluding Sections “22.1 Maxwell solid” and “22.2 Kelvin-Voigt solid”.

Chapter 23; Read from the beginning of the chapter to Equation (23.9) [not included] and then from the beginning of Section 23.2 to Equation (23.33). Read Sections 23.3 and 23.4.

Chapter 24; Have a brief look at Equation (24.17) and be aware that you understand the physical meanings of its terms.

Chapter 25; Have brief look from the beginng to the end of the paragraph below Equation (25.5). Be sure that you know the physical meaning of the microcrack densities Q^r introduced in Equation (25.4)

Chapter 26; Read.

Chapter 27; Read the text before Section 27.1 and Section 27.1. Sections 27.2 and 27.3 are very important. Especially Figures 27.4 and 27.5 and the text related to them needs special attention. Be sure that you can derive Expression $(27.12)_1$. Read Section 27.4 and be sure that you can derive Result (27.32). Skip Section 27.5. Have a brief look at Section 27.6 to but skip the end of the section starting from Equation (27.70). Skip Section 27.7. Read Section 27.8 and skip Section 27.9. In Section 27.10 headed "Other types of damage" be ready to explain the micromechanical roles of the components in Expressions (27.118) and to draw a figure like Figure 27.13. Read Section 27.11 briefly

Chapter 28; Skip

Chapter 29; Skip.

Appendices; I have prepared a collection of the main results of the appendices. You can take it with you to the examination. Make sure that you understand the content of this collection.

Extended L-M Method; Chapter 3. Especially the derivation of the Levenberg-Marquardt method starting from Expression (3.8) and continuing to Equation (3.16). The iteration procedure on page 20 is also important.

The material on the implementation of the material model into Abaqus-UMAT.