Workshop within the Erasmus cooperation

Instructor: Prof. Dr.-Ing. Stefan Hartmann

Institute of Applied Mechanics, Division of Solid Mechanics

Faculty of Mathematics/Computer Science and Mechanical Engineering

Clausthal University of Technology, Germany

www.itm.tu-clausthal.de

Monday, October 9, 2017

Place: Δ3.004 Seminar room of the School of Production Engineering and Management, Technical University of Crete

Non-linear finite elements of coupled problems

9:00 – 10:30 Lecture

Coffee break

11:00 – 12:30 Lecture

Lunch break

14:00 – 15:30 Lecture

Course Objective

The numerical treatment of incorporating constitutive models of solid materials in finite element programs is already known. This course, however, treats the interpretation of the entire space and time integration, where the results of spatial discretization using finite elements will yield, depending on the underlying problem, systems of algebraic, ordinary differential or even their combinations, i.e. differential-algebraic equations (DAE). The solution of these systems, particularly, of time-dependent problems (models of viscoelasticity, rate-independent plasticity, viscoplasticity, and thermo-mechanically coupled problems) is treated.

Course Outline

1. Recapitulation of 3D small strain elasticity
2. Viscoelasticity, rate-independent plasticity, viscoplasticity
3. Principle of virtual displacements and its discretization using finite elements
4. Temporal discretization using the Backward-Euler method to solve DAEs
5. Newton-Raphson method versus Multilevel-Newton method
6. Higher order time discretization using diagonally-implicit Runge-Kutta methods
7. Time-adaptivity
8. Extension to finite deformations
9. Thermo-mechanics
10. (Thermo-)Dynamics

Reference Texts (recommended):

• Ellsiepen, P. and Hartmann, S. (2001). Remarks on the interpretation of current non-linear finite-element analyses as differential-algebraic equations. *International Journal for Numerical Methods in Engineering* **51**:679–707.
• Hartmann, S. (2002). Computation in finite strain viscoelasticity: finite elements based on the interpretation as differential-algebraic equations. *Computer Methods in Applied Mechanics and Engineering* **191**(13-14):1439–1470.
• Hartmann, S. (2005). A remark on the application of the Newton-Raphson method in non-linear finite element analysis. *Computational Mechanics* **36**(2):100–116.
• Grafenhorst, M., Rang, J., Hartmann, S. (2017): Time-adaptive finite element simulations of dynamical problems for temperature-dependent materials, *Journal of Mechanics of Materials and Structures* **12**(1), 57 – 91.

A manuscript on *Theory of Materials* will be provided.

Tuesday, October 10, 2017

Place: Δ3.004 Seminar room of the School of Production Engineering and Management, Technical University of Crete or Foreign Languages Center, Technical University of Crete

9:00 – 10:30 Identifiability and identification using nonlinear finite elements

11:00 – 13:00 Welche Bedeutung hat die Technische Mechanik in der Ingenieurausbildung?

A talk in German, addressed to students and co-workers of Technical University of Crete learning the German language, in cooperation with Mrs Anna Vrouvaki, from the Center of Foreign Languages.

Biographical sketch of the Instructor

Professor Hartmann's research interests are experimental mechanics for solid materials, constitutive modelling, finite elements of coupled problems with the focus on high order time integration, and material parameter identification. He published 50 journal papers, 80 scientific contributions, and 2 books on applied mechanics. He also (co-)edited 6 books/journal special issues and co-organized numerous meetings. Prof. Hartmann is member of the Association of Applied Mathematics and Mechanics (GAMM) and the German Association of Computational Mechanics (GACM), Chairman of the national section of the GAMM (DeKoMech), and Vice-President of the Clausthal Association of Applied Mechanics (CFAM).

Further details can be found in the web page of his Institute

https://www.itm.tu-clausthal.de/

For further information please contact:

Professor Georgios Stavroulakis (gestavr@dpem.tuc.gr)

Institute of Computational Mechanics and Optimization (www.comeco.tuc.gr)

School of Production Engineering and Management

Technical University of Crete