SCHOOL OF ENGINEERING
JÖNKÖPING UNIVERSITY

COURSE SYLLABUS – THIRD-CYCLE EDUCATION

Computational Contact Mechanics, 9 higher education credits

Education cycle:	Third-cycle education
Disciplinary domain:	Industrial Product Realization
Subject area:	Machine design
Syllabus valid from:	Course syllabus reviewed by RUF 2012xxxx, established 2012xx by head of research and doctoral program)
Version	First version

Learning outcome

Knowledge and understanding
After finishing the course the participants will have a theoretical foundation for computational contact mechanics. In particular for studying contact problems appearing in assemblies of machine components.

Skills and abilities
The participants will be able to develop and implement methods for solving contact problems appearing in assemblies of machine components.

Content

Mechanical systems such as gears and brakes are connected via contact interfaces. The understanding of these systems is much based on the understanding of the behavior of the corresponding contact interfaces including phenomena such as friction and wear. In this course finite element based methods for simulating contact problems appearing in interfaces of mechanical systems are presented.

In particular the course will cover the following topics:

- Signorini's contact conditions
- Coulomb's law of friction
- Arhard's law of wear
- The augmented Lagrangian approach
- Uzawa's method and Newton's method
- Standard material
- Soft contact

- Frictional heating
- Fretting fatigue
- Impact of bodies
- Large rotations and displacements
- Transmission error
- The mortar approach

Three obligatory home assignments are also included in the course. The assignments concern computer implementations of methods presented in the course. The assignments are presented briefly below.

Assignment 1

The augmented Lagrangian formulation of a two-dimensional linear elastic body in unilateral contact with a rigid foundation solved with Uzawa's and Newton's method. The two methods are implemented using Matlab. The numerical results are compared to results obtained by using any commercial software such as Abaqus, Ansys, LS-Dyna, etc.

Assignment 2

Including friction in assignment 1.

Assignment 3

Expanding assignment 1 and 2 in order to study a thermo-elastic body subjected to frictional heating.

Type of instruction

Lectures and home assignments are given in English.

Prerequisites

Students should have a MSc in Mechanical Engineering, specializing in product development or related topics. Students who have corresponding knowledge obtained from experience or study of other disciplines will be considered on an individual basis.

Examination and grades

Grades passed or failed based on the reports of the home assignments and a written examination.

Course literature

- N. Strömberg, Nonlinear FEA and Design Optimization for Mechanical Engineers, www.fema.se, 2012.
- N.Strömberg, L.Johansson & A.Klarbring, Derivation and analysis of a generalized standard

model for contact, friction and wear, *International Journal of Solids Structures*, **33**, 1817-1836, 1996.

- N.Strömberg, An augmented Lagrangian method for fretting problems, *European Journal of Mechanics, A/Solids* **16**, 573-593, 1997.
- N. Strömberg, A Newton method for three-dimensional fretting problems, *International Journal of Solids Structures* **36**, 2075-2090, 1999.
- N. Strömberg, Finite element treatment of two-dimensional thermoelastic wear problems, *Computer Methods in Applied Mechanics and Engineering*, **177**, 441-455, 1999.
- P.Ireman, A.Klarbring & N.Strömberg, Finite element algorithms for thermoelastic wear problems, *European Journal of Mechanics, A/Solids*, **21**, 423-440, 2002.
- N.Strömberg, A method for structural dynamic contact problems with friction and wear, *International Journal for Numerical Methods in Engineering*, **58**, 2371-2385, 2003.
- P.Ireman, A.Klarbring & N.Strömberg, A model of damage coupled to wear, *International Journal of Solids and Structures*, **40**, 2957-2974, 2003.
- A. Klarbring, O. Lundvall & N.Strömberg, A flexible multi-body approach for frictional contact in spur gears, *Journal of Sound and Vibration*, **278**, 479-499, 2004.
- N.Strömberg, An Implicit Method for Frictional Contact, Impact and Rolling, *European Journal of Mechanics, A/Solids*, **24**, 1016-1029, 2005.
- P.Ireman, A.Klarbring & N.Strömberg, Gradient Theory of Damage Coupled to Frictional Contact and Wear, and Its Numerical Treatment, *Computer Modeling in Engineering Science*, **52:2**, 125-158, 2009.
- N. Strömberg, An Eulerian Approach for Simulating Frictional Heating in Disc-Pad Systems, *European Journal of Mechanics, A/Solids*, **30**, 673-683, 2011.
- N.Strömberg & J.F. Massana, A soft contact formulation for modelling thin coatings, in the proceedings of *Contact/Surface, the Seventh International Conference on Computer Methods and Experimental Measurements for Surface Effects and Contact Mechanics*, September 5-7, Bologna, Italy, 2005.