UNIVERSITY OF CHEMICAL TECHNOLOGY AND METALLURGY
CENTRE OF MATERIALS SCIENCE

Affirmation: ....

SYLLABUS

Subject: Finite Element Method

Specialty: Materials Science and Engineering

Degree: Master of Science

Professional Qualification: Master - Engineer in Materials Science

Created by:

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I. HOURS (according to the academic curriculum)

Classes	Semester	Duration (academic sessions of 45 minutes)	
		weekly	all
1. Lectures	II	2	10
2. Seminars	II	1	20
3. **Control**	Exam		
4. ECTS Credit	Auditorium work: 1,5 credits; Home work: 1,5 credits; All: 3,0 credits		

II. Annotation

The course is designed to teach engineers how to use finite element methods (FEM) to solve problems in the materials science. The FEM is a powerful technique applied in almost every aspect of engineering, from the analysis of cardiac tissue to the behavior of superconducting magnets for high-speed trains. The primary goal of the course is to provide students with a fundamental understanding of FEA concepts, their strengths, and their limitations in the context of real materials-related problems (mechanical and thermodynamic properties, phase transformations, microstructure evolution during processing). The students will learn basic theory, how to use FEM software and how to interpret results, so that they will be able to adapt the techniques to fit engineering problems that they will encounter in the future. Pertinent mathematical and mechanics background material will be reviewed briefly if needed. A large part of the course is conducted in the computer laboratory. After the successful completion of the course, the students will be able to

1. Formulate a finite element problem from "real world" materials.
2. Identify the constitutive equations and assumptions that drive the system.
3. Model the systems from various types of materials in a manner amenable to FE solution techniques.
4. Determine appropriate system constraints and boundary conditions.
5. Utilize a commercial finite element package *(ANSYS Multiphisics / ANSYS CFX, academic license)*
6. Discuss the validity and accuracy of the results of a FE analysis.

Homework is an essential part of this course. Various programming and formulation problems will be assigned through the class website. There will be a project related to computer implementation of material properties, using commercial programs. Here the students are encouraged to learn certain aspects of the software on their own as an exercise in self-education.

III. Contents of the Lectures

1. **Finite Element Method: Introduction and Theory ....2 hours**
   Engineering problems, numerical methods, basic steps in the FEM, direct formulation, minimum total potential energy formulation, ' example of one-dimensional element.

2. **Software Packages: ANSYS Multiphisics / ANSYS CFX .... 1 hours**
   The ANSYS environment, graphical user interface (GUI), pre-and post-processors, element types, using the ANSYS session and command logs, model and mesh generation.

3. **Material Models for FE Structural Analysis .... 2 hours**
   Material model interface for mechanical properties, non-linear elastic materials, orthotropy, hyper elasticity, viscoelasticity, plasticity.

4. **Material Models for FE Thermal Analysis .... 2 hours**
   Material model interface for thermal properties, conductivity, specific heat, enthalpy, emissivity, convection or film coef, heat generation rate.

5. **Material Models for FE Fluids Analysis .... 2 hours**
   Material model interface for CFD properties, viscosity, emissivity, density, • conductivity, specific heat.

6. **Material Models for FE Electromagnetic Analysis .... 1 hours**
   Material model interface for electromagnetic properties, relative permeability and permittivity, resistivity, coercive force.

IV. Seminars

1. **Static Analysis of a Corner Bracket. Influence of the Material Properties on the Results ....4 hours**
   Solid modeling including primitives, Boolean operations, and fillets; tapered pressure load; deformed shape and stress displays; listing of reaction forces.

2. **Solidification of a Casting. Influence of the Material Properties on the Results ....4 hours**
   Conduction, convection, phase change, selecting, solution control, time-history postprocessing, use of a "get function".

3. **Ceramic bricks baking in a tunnel kiln. Influence of the Material Properties on the Results ....4 hours**
   Simulation of a transient heat transfer according a temperature curve. Investigation the material properties influence to the heat transfer process.

4. Slide Film Damping. Influence of the Material Properties on the Results .... 4 hours

Utilization of FLUID 139 elements for modeling the lateral and vertical damping of the comb drive assembly consisting of fixed and moving comb drives, springs, and a central mass.

5. Multiphysics Analysis of a Thermal Actuator. Influence of the Material Properties on the Results .... 4 hours

Importing an IGES model, SmartSizing, selecting entities, applying voltage, temperature, and displacement boundary conditions, plotting voltage, temperature, and displacement results, animating displacement results, listing heat flow and current.

V. Text books:

1. O. C. Zienkievicz, ***The Finite Element Method in Engineering Science.*** MCGRAW-HILL, London, 1971

2. S. Moaveni, ***Finite Element Analysis.*** Prentice Hall, Upper Saddle River, New Jersey, 1999.

3. Ted Belytschko, ***Finite Elements for Nonlinear Continua and Structures.*** Northwestern University, Chicago, 1996

Reference Materials:

1. ***Release 10.0 Documentation for ANSYS.*** ANSYS Inc., Canonsburg, PA, USA, 2005.

2. A.D. Burns and P.J. Zwart, ***Computational Fluid Dynamics Modeling of Multi-Phase Flows,*** Alpha Beta Numerics, Preston, UK, 2005.

3. P. Lethbridge, ***Emag 9.0 Technology Overview & Benefits,*** ANSYS Inc., Canonsburg, PA, USA, 2005.

4. ***Multiphysics Simulation for MEMS,*** TRAINING MANUAL, Inventory #001796, ANSYS Inc., Canonsburg, PA, USA, February, 2003.

5. R. Browell, ***Robust Design,*** ANSYS Inc., Canonsburg, PA, USA, 2005.

6. ***Heat Transfer*** TRAINING MANUAL, Inventory #002180, ANSYS Inc., Canonsburg, PA, USA, April, 2005.

7. C Kurt Svihla, ***ANSYS CFX-5 Test Drive.*** ANSYS Inc., Canonsburg, PA, USA, May 23, 2004.

8. ***CivilFEMINTRO,*** INGECIBER, s.a.,2005