FACULTY OF **ENGINEERING**

DEGREE COURSE: **INDUSTRIAL ENGINEERING**

MASTER DEGREE: **INDUSTRIAL ENGINEERING / DESIGN**

SUBJECT: CONTINUUM MECHANICS

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OBJECTIVES

The course aims to provide a deep understanding in Structural Engineering and to introduce advanced topics in Structural Mechanics, with the objective of acquiring the necessary technical aspects for the analysis of complex structural systems.

CONTENTS

1. STATICALLY INDETERMINATE SYSTEMS OF BEAMS

Principle of virtual work (P.V.W.) for beams: theorem of virtual work (T.V.W.), theorem of virtual displacement (T.V.D.), theorem of virtual forces (T.V.F.) – Calculation of displacements via P.V.W. – Solution of statically indeterminate structures via the force method: Müller-Breslau equations – Effect of distorsions

2. STABILITY OF THE ELASTIC EQUILIBRIUM

Quality of the equilibrium – Instability of structures with concentrate deformability – Euler problem – Other constraints conditions – Introduction to the “omega” method

3. GENERALIZATION OF THE BENDING PROBLEM

Curved beams – Elasto-plastic bending – Elastic moment and plastic moment – Introduction to plastic

analysis of beams

4. ADVANCED KINEMATICS OF A CONTINUUM

Large deformation kinematics – Deformation gradient – Polar decomposition theorem – Right and left Cauchy-Green tensor, Green-De Saint Venant tensor – linearized kinematics

5. ADVANCED STATICS OF A CONTINUUM

Cauchy system of forces – Euler's axioms – Work – Measures of stress: Cauchy stress tensor, first and second Piola-Kirchhoff stress tensor – Introduction to live loads and dead loads – Linearized statics

6. FINITE ELASTICITY

Invariance under a change of observer (axiom of objectivity) – Isotropic and anisotropic materials – Rivlin-Ericksen representation theorem – Hyperelastic materials – Examples of elastic materials (Mooney-Rivlin, Ogden, Neo-Hookean, De Saint Venant-Kirchhoff) – Linearization – Elastic tensor

7. LINEARIZED ELASTICITY

From finite elasticity to linearized elasticity – The elastic problem – Compatibility equations – Theorem of uniqueness of the solution (Kirchhoff) – Clapeyron's theorem and Betti's theorem – Introduction to influence lines – Displacement method: Navier equations – Force method: Beltrami-Michell equations – Solution of De Saint Venant's problem

8. PLANE ELASTIC PROBLEM

Plane strain – Plane stress (generalized) – Airy function – Williams problem – Introduction to fracture mechanics

9. VARIATIONAL PRINCIPLES AND APPROXIMATE SOLUTIONS

Principle of stationary potential energy – Approximate

solutions via Ritz method – Approximate solutions via Galerkin method – Equivalence between Galerkin method and Ritz method – Hu-Washizu Principle – Introduction to the application of the mixed finite element method

LEARNING OUTCOMES

At the end of the course the student will be able to solve complex structures and to address structural problems of interest in both classical and modern applications.

ASSESSMENT

Written exam: multiple choice and open questions

RECOMMENDED TEXTBOOKS

Ciarlet, “Mathematical elasticity, vol. I”, North-Holland
Gurtin, “An introduction to continuum mechanics”, Academic Press
Gurtin, “The linear theory of elasticity”, in Handbuch der Physik, Bd. VIa/2
Gere, Timoshenko, “Mechanics of materials”
Bazant, Cedolin, “Stability of structures”, World Scientific
Lenci, “Lezioni di meccanica strutturale”, Pitagora
Reddy, “An introduction to continuum mechanics – with applications”, Cambridge University Press
Lai, Rubin, Krempl, “Introduction to continuum mechanics”, Elsevier
Marsden, Hughes, “Mathematical foundations of elasticity”, Dover
Love, “A treatise on the mathematical theory of elasticity”, Dover