UNIVERSITÀ DI PAVIA

Anno Accademico 2021/2022

ADVANCED SOLID AND STRUCTURAL MECHANICS

Enrollment year	2020/2021
Academic year	2021/2022
Regulations	DM270
Academic discipline	ICAR/08 (CONSTRUCTION SCIENCE)
Department	DEPARTMENT OF ELECTRICAL,COMPUTER AND BIOMEDICAL ENGINEERING
Course	BIOENGINEERING
Curriculum	Cellule, tessuti e dispositivi
Year of study	2°
Period	1st semester (27/09/2021 - 21/01/2022)
ECTS	6
Lesson hours	45 lesson hours
Language	English
Activity type	WRITTEN AND ORAL TEST
Teacher	AURICCHIO FERDINANDO (titolare) - 4 ECTS SCALET GIULIA - 2 ECTS
Prerequisites	Knowledge of the concepts given within the courses of Rational Mechanics and Structural Mechanics.
Learning outcomes	The course aims to advance the knowledge and understanding of the mathematical and physical foundations of continuum mechanics of solids and to enhance the ability to apply its principles to solve structural engineering problems.
Course contents	• An introduction o Mechanics of deformable solids: definition o Model construction vs physical reality o Mechanical modeling basic ingredients: kinematics, equilibrium, constitutive equations

• Review on vector and tensors
o Vectors and tensors: an introduction
o Compact, indicial, engineering/Voigt notations
o Operations between vectors and tensors
o Vector and tensor calculus

• Review of solid mechanics (and notation) from basic courses (I)
o Kinematics
? change of configuration, reference & current configuration; reference configuration as a natural one for kinematics
? displacement field, gradient of change of configuration, Cauchy-Green deformation tensor, Green-Lagrange strain tensor
? Fundamental assumptions: small displacement gradient; interpretation of displacement fields in terms of rigid body and strain quotas
o Equilibrium
? current configuration as a natural one to study equilibrium
? external & internal actions, equilibrium for a deformable body in a integral format
? Principle of action/reaction, Cauchy stress tensor
o Principle of virtual work

• Review of solid mechanics (and notation) from basic courses (II)
o Material response and constitutive relations
o Green elasticity
o Isotropy

• Variational & energy-based formulations for 3D problems
o Minimum of free energy
o Minimum of complementary free energy
o Hellinger-Reissner and Hu-Washizu principles

• Plane beam model (1D structural model)
o Kinematic assumptions and beam-like strains
o Equilibrium from principle of virtual work and beam resultants
o Beam constitutive equations
o Euler-Bernoulli beam model
o Timoshenko beam model

• Plate model (2D structural model)
o Kinematic assumptions and plate-like strains
o Equilibrium from principle of virtual work and plate resultants
o Plate constitutive equations
o Kirchhoff-Love plate model
o Reissner-Mindlin plate model

• Principle of virtual work for (planar) beam
o PVW of planar beam problems
o Use of PVW to solve simple beam problems
o Use of PVW to solve over-constrained beam problems

• Energy-based formulations for 1D and 2D problems
o Derivation of Timoshenko plane beam model
o Derivation of Reissner-Mindlin plate model

	o Elasticity vs inelastic material response in terms of energy and dissipation • Limit analysis basic concepts and applications to beam problems o Simple truss structures: limit analysis o Kinematic theorems o Equilibrium theorems o Simple beam structures: limit analysis • Solid mechanics: finite strain extension o Kinematics ? Strain measure in the current configuration ? Push-forward and pull-back concept o Equilibrium ? First and second Piola-Kirchhoff stress tensor • Simple 1D structural theories: finite strain extension • Basic concepts of instability of structures
Teaching methods	Blackboard lectures, slide lectures, Mathematica-based hands-on tutorials. The course will be held in English if the percentage of non-native Italian students is greater than 25%.
Reccomended or required readings	- Lecture notes; - K.D. Hjelmstad, Fundamentals of Structural Mechanics, Second Edition, Springer; - L. Corradi dell'Acqua, La meccanica delle strutture, vol. 3, McGraw Hill (in particular, chap. 13 for limit analysis); - O. Zienkiewicz, R.L. Taylor, J.Z. Zhu, The Finite Element Method: Its Basis and Fundamentals, Butterworth-Heinemann, 2013.
Assessment methods	The exam consists in a written evaluation, an oral discussion, and the assignment of Mathematica-based homework.
Further information	
Sustainable development goals - Agenda 2030	$lbl_legenda_sviluppo_sostenibile