INSTITUTO POLITÉCNICO DE BRAGANÇA

Course Unit	Solids and Materials Biomechanics			Field of study	Biomatrials and Biomechanics								
Bachelor in	Biomedical Technology			School	School of Technology and Management								
Academic Year	2023/2024	Year of study	2	Level	1-2	ECTS credits	6.0						
Type	Semestral	Semester	2	Code	9600-752-2202-00-23								
Workload (hours)	162	Contact hours	T -	TP 60	PL -	TC -	S -	E -	OT -	O -			

T - Lectures; TP - Lectures and problem-solving; PL - Problem-solving, project or laboratory; TC - Fieldwork; S - Seminar; E - Placement; OT - Tutorial; O - Other

Name(s) of lecturer(s): David Andre Bento, Luís Manuel Ribeiro Mesquita

Learning outcomes and competences

At the end of the course unit the learner is expected to be able to:
1. Calculate stresses in structural elements subject to axial, torsional, transverse and bending static loading.
2. Identify elastic mechanical properties and typical values of yield strength.
3. Identify the structure and properties of bone tissues.
4. Analyse and interpret stresses and strains in biomechanical systems.
5. Apply the theories of elastic failure to the components design.
6. Analyse a wide range of problems in Materials and Solids Biomechanics using suitable theoretical methods.
7. Study independently, use library resources and manage working time.

Prerequisites

Before the course unit the learner is expected to be able to:
1. Understand the fundamental principles of Maths and Physics.
2. Apply the concepts of Applied Biomechanics.

Course contents

Normal and shear stress. Normal strain. Axial loading, elastic and plastic material properties. The mechanical properties of cancellous and cortical bone. Skeletal system. Stress concentrations, bone screws and effects of holes. Beam theory, bending, torsion and bone-implant systems. Elastic curve. Theory of elasticity. Hooke's law. Isotropy, orthotropic and anisotropy constitute relations. Mohr's circle for stresses and strains. Strain gauge rosettes. Ductile and fragile theories of failure.

Course contents (extended version)

1. Stress and Axial Loading
   - Axial Loading and normal stress. Shearing and bearing stresses.
   - Application to the analysis and design of simple structures.
   - Stress on an Oblique Plane. Yield and safety stress. Safety factor.
   - Static Analysis of the Skeletal System.
2. Materials Properties and Bone Tissues
   - Stress-strain diagram. Modulus of Elasticity.
   - Elastic versus plastic behavior. Plastic deformation. Elasto-plastic and perfect material.
   - Poisson's ratio. Multiaxial loading; Generalized Hooke's Law.
   - Tissue Mechanics. Composition of bone. Cortical and trabecular bone.
   - Problems involving temperature changes.
   - Stress Concentrations.
3. Torsion
   - Stresses and deformations in a circular structure in the elastic range.
   - Twist angle in elastic range.
   - Torsion of noncircular members and thin-walled hollow structures.
   - Applications in musculoskeletal system.
4. Pure Bending and Transverse Loading
   - Stresses and deformations in the elastic range.
   - Eccentric axial Loading in a plane of symmetry. Unsymmetrical bending.
   - General case of eccentric axial loading.
   - Applications in musculoskeletal system.
5. Bending Elements Analysis
   - Shear and bending-moment diagrams.
   - Relations among load, shear, and bending moment.
   - Equation of the elastic curve. Slope and deflection determination.
   - Musculoskeletal system and design advanced topics.
6. Stresses and Strains in Elastic Bodies
   - Components of stress and strains. Equilibrium and compatibility equations.
   - Transformation law. Principal stresses and strains. Maximum shear stress and strain.
   - Mohr's circle for two dimensional stresses and strains.
   - Constitute models of material behaviour: anisotropic, orthotropic and isotropic.
   - Elastic energy deformation.
   - Failure by Yielding: Tresca, von-Mises, Mohr.
   - Measurement of strain using strain gauge rosettes.
   - Some applications in orthopaedic systems.

Recommended reading

1. Ferdinand P. Beer, E. Russel Johnston Jr, John T. DeWolf, Mechanics of Materials, McGraw-Hill, 2002. ISBN: 0-07-112167-6.
2. António Completo, Fernando Fonseca, Fundamentos de Biomecânica - Musculo-esquelética e ortopédica, Publindústria, Edições Técnicas, 2011. ISBN: 978-972-8953-70-6.
3. John D. Currey, Bones: Structure and Mechanics, Princeton University Press, 2006. ISBN: 0-691-12804-9.
4. Donal L. Bartel, Dwight T. Davy, Tony M. Keaveny, Orthopaedic Biomechanics: Mechanics and Design in Musculoskeletal Systems, Pearson Prentice Hall Bioengineering, 2006.

Teaching and learning methods

Methodologies: theoretical lessons with different methodologies presentation. Application of theoretical concepts in practical lectures through the problems resolution, given in class and homework. Lessons taught in portuguese with support in english for international students.

Assessment methods

1. Alternative 1 - (Regular, Student Worker) (Final)
   - Intermediate Written Test - 40%
   - Final Written Exam - 60%
2. Alternative 2 - (Regular) (Supplementary, Special)
   - Final Written Exam - 100%
3. Alternative 3 - (Student Worker) (Final, Supplementary, Special)
   - Final Written Exam - 100%

Language of instruction

Portuguese, with additional English support for foreign students.

Electronic validation

David Andre Bento, Luís Manuel Ribeiro Mesquita	Debora Rodrigues de Sousa Macanjo Ferreira	Joana Andrea Soares Amaral	José Carlos Rufino Amaro
27-02-2024	27-02-2024	15-03-2024	24-03-2024