2EL1820 – Biomechanics and life materials

Instructors: Elsa Vennat
Department: DÉPARTEMENT MÉCANIQUE ENERGÉTIQUE PROCÉDÉS
Language of instruction: FRANCAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 60
On-site hours (HPE): 35,00
Elective Category : Engineering Sciences
Advanced level : Yes

Description

The link between mechanics and life is much stronger than we might think at first glance. Did you know that our bone tissue evolves and adapts according to the mechanical load it is subjected to? This is important in our daily life (regular moderate physical activity leads to better bone quality) but also in medical care (how to replace or regenerate bone tissue after an accident?).

In this course we will discuss the links between mechanics and life, from biomechanics to mechanobiology.
Tools will first be put in place to describe, model and solve a mechanical problem where living materials are involved: reminders of Continuous Media Mechanics, anisotropy of natural composites, viscoelasticity of soft tissues, introduction and application of the finite element method to solve problems of increasing complexity.
In a second phase, these tools will be used to characterise and model a living material of your choice (bone, tooth, cells, wood...) in a series of numerical and experimental assignments. Living materials are by nature multi-scale. A complete approach will be taken to characterise and model the chosen living material in three stages:

- Bibliographic research (presentation of tools and research by group)
- Observations at the various relevant scales: observation of samples under the microscope, three-dimensional visualisation of the microstructure, image processing and analysis.
- Experimental study of material's behaviour (cells under stress, tissues under loading, etc.), finite element modeling and critical analysis

All practical work can be switched to distance learning if needed.

Quarter number
SG8
Prerequisites (in terms of CS courses)

1EL5000 - Mécanique des milieux continus

Syllabus

- Modeling the behaviour of materials:
- Continuum Mechanics (recalls)
- Anisotropy of natural composites
- Viscoelasticity of soft tissues

- Experimental and numerical approach:
    - Introduction to bibliographic research
    - (morphological and mechanical) characterization/modelling of tissues or cells in an experimental and numerical way
- Opening seminar with the participation of researchers working on "Biomechanics" in the broad sense

Class components (lecture, labs, etc.)
12h course ; 21h pratical work

Grading
Continuous control (40% of the mark) ; oral and/or report on practical work (60% of the mark)
The practical work sessions are mandatory.

Resources
Teacher : Elsa VENNAT
Softwares : Comsol Multiphysics, ImageJ (or FIJI)

Learning outcomes covered on the course
At the end of this course, the students will be able to, among other things:

- describe the behaviour of biological tissues from experimental curves,
- use the symmetries of its morphology to propose a simplified form for its rigidity matrix,
- propose an experimental protocol to characterize a tissue in tension/compression and to analyse the results of such a test,
- describe the tests to characterize the viscoelasticity of a tissue,
- propose a rheological model to model the viscoelastic behaviour of a tissue,
- conduct a bibliographic study,
- characterize a porous biological tissue by image analysis using ImageJ software,
- propose a finite element model of this porous medium to evaluate its Young's modulus or permeability