COURSE DESCRIPTION
MECHANICS IN TISSUES AND GROWTH

SSD: TECNICA DELLE COSTRUZIONI (ICAR/09)

DEGREE PROGRAMME: BIOINGEGNERIA INDUSTRIALE (P16)
ACADEMIC YEAR 2024/2025

COURSE DESCRIPTION

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GENERAL INFORMATION ABOUT THE COURSE

INTEGRATED COURSE: NOT APPLICABLE
MODULE: NOT APPLICABLE
TEACHING LANGUAGE: INGLESE
CHANNEL: FG A-Z
YEAR OF THE DEGREE PROGRAMME: II
PERIOD IN WHICH THE COURSE IS DELIVERED: SEMESTER I
CFU: 6

REQUIRED PRELIMINARY COURSES

Biomechanics.

PREREQUISITES

Basic concepts of continuum mechanics.

LEARNING GOALS

The course aims to provide the basic knowledge of the mechanics of growth in living systems, with particular focus on the biological tissues. Students will acquire specific skills on the mechanical characterization of this biological phenomenon, both at the molecular and macroscopic level, using engineering tools such as analytical and numerical formulations. Topics of particular relevance covered in the course are those related to: the classification of growth-related changes affecting biological systems; the mechanical modelling of growth based on the continuum theory; the differentiation of available numerical modelling approaches as a function of changes in volume, area or fibre morphology. Specific issues regarding growth-related tissue biology (e.g., growth

factors) will also be addressed in the course. A part of the course will be devoted to the implementation of constitutive equations using finite element tools for growth modelling with reference to specific case studies.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

The scientific contents consist in the application of the theories and techniques related to the structural concepts, actions and behaviours corresponding to the typologies/morphologies of the materials and technologies.

Applying knowledge and understanding

Through practical exercises.

COURSE CONTENT/SYLLABUS

1. **Introduction** Growth of living systems: definitions and examples Natural phenomena of growth
2. **Biomechanical aspects of growth** Historic overview and modern trends Culmann's crane Wolff's law and Roux's adaptation concept
3. **Geometrical features of growth in living systems** Dimensional growth of living systems Geometrical modeling
4. **Classification of growth in living systems** Growth-induced microenvironmental changes Mechanically-induced microstructural changes
5. **Growth factors (GFs)** Hormone releasing factors, epidermal GF, endothelial GF, fibroblast GF GFs in blood vessels and tissues, nutrients
6. **Continuum modeling of growth** General principles Kinematic changes of growing bodies Deformation gradient and its decomposition Set of constitutive equations for continuum modeling of growth
7. **Mechanics of volume growth** Constitutive equations: mechanical characterization Examples: nutrient driven volume growth of tumors; stress driven volume growth of arteries
8. **Mechanics of area growth** Constitutive equations: mechanical characterization Examples: area growth of airway walls (growth factor driven); strain driven area growth of skin and tissues; area growth of valve leaflet
9. **Mechanics of fiber growth** Constitutive equations: mechanical characterization Examples: fiber growth of plant stems (hormone driven); stretch driven fiber growth of skeletal muscle; fiber growth of heart valve annuli.
10. **Exercises and FE implementations**

READINGS/BIBLIOGRAPHY

Y. C. Fung, Biomechanics: Motion, Flow, Stress, and Growth. Springer. Hardcover ISBN978-0-387-97124-7

Lecture notes

TEACHING METHODS OF THE COURSE (OR MODULE)

Lectures and practical exercises.

EXAMINATION/EVALUATION CRITERIA

a) Exam type

- [x] Written
- [ ] Oral
- [x] Project discussion
- [ ] Other

In case of a written exam, questions refer to

- [ ] Multiple choice answers
- [x] Open answers
- [ ] Numerical exercises

b) Evaluation pattern

Weighted sum between project work and written exam.