ME-484

Numerical methods in biomechanics

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Cursus	Sem.	Type
Bioengineering	MA4	Opt.
Life Sciences Engineering	MA2, MA4	Opt.
Mechanical engineering minor	E	Opt.
Mechanical engineering	MA2, MA4	Opt.
Robotics	MA2, MA4	Opt.

Language of teaching	English
Credits	3
Session	Summer
Semester	Spring
Exam	Written
Workload	90h
Weeks	14
Hours	**3 weekly**
Courses	2 weekly
Exercises	1 weekly
Number of positions	

Summary

Students understand and apply numerical methods (FEM) to answer a research question in biomechanics. They know how to develop, verify and validate multi-physics and multi-scale numerical models. They can analyse and comment results in an oral presentation and a written report.

Content

- Use of numerical methods in biomechanics through some examples (tissue engineering, mechanical biology, artificial organs, external lectures from academics and industry)
- Partial Differential Equations reviewed in this context.
- General physics (solid, fluid, heat, transport) reviewed and extended through examples.
- Finite Element Method explained through practical examples.
- Multi-physics and coupling problems
- Importance of verification and validation
- Practical examples discussed in classroom
- Weekly exercises in different fields of biomechanics
- Group projects

Keywords

Biomechanics, numerical methods, multi-physics, coupling

Learning Prerequisites

Important concepts to start the course

- Partial Differential Equations
- Linear algebra
- General Physics (solid, fluid, heat)
- Numerical analysis

Learning Outcomes

By the end of the course, the student must be able to:

- Compute the kinematics and the forces in articulations, B3
- Compute shear stresses in blood in particular flow conditions, B4
- Compare the range of validity of different constitutive laws, B7
- Implement a constitutive law in a simulation software, B8
- Describe the feedback loop that, starting from a mechanical signal translated into a chemical signal, allows for the adaptation of the mechanical properties of tissues, B9
- Compute the stresses and strains at the interface of an implant and in the surrounding tissues, B10
- Compute the kinematics and forces in an implant, B11

Transversal skills

- Set objectives and design an action plan to reach those objectives.
- Identify the different roles that are involved in well-functioning teams and assume different roles, including leadership roles.
- Continue to work through difficulties or initial failure to find optimal solutions.
- Take feedback (critique) and respond in an appropriate manner.
- Access and evaluate appropriate sources of information.
- Write a scientific or technical report.
- Make an oral presentation.

Teaching methods

The course is divided into ex cathedra sessions, with interactive examples. Exercises are organised to applied concepts presented in the course. A mini-project is carried out in groups. Examples, exercises and mini-projects are done with Comsol.

Expected student activities

- Attend cours and do interactive exemples
- Do the exercices
- Do a project in a group

Assessment methods

- Midterm summary report (1/4)
- Oral presentation of project (1/4)
- Written rapport of project (1/4)
- Remote open book exam (1/4)

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

Resources

Bibliography

Computational Modeling in Biomechanics, 2010
http://library.epfl.ch/ebooks/?pg=search&isbn=978-90-481-3574-5

Ressources en bibliothèque

- Computational Modeling in Biomechanics / Suvranu

Moodle Link

- http://moodle.epfl.ch/course/view.php?id=14383