

ME-484

**Numerical methods in biomechanics**

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Cursus	Sem.	Type
Biomedical technologies minor	E	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
<b>Hours</b>	<b>3 weekly</b>
Courses	2 weekly
Exercises	1 weekly
<b>Number of positions</b>	

**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 test or summary report (1/4)
- Oral presentation of project (1/4)
- Written rapport of project (1/4)
- Writtn exam (1/4)

### 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

- <https://go.epfl.ch/ME-484>