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
• 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
• Midtem text (1/4)
• Oral presentation of project (1/4)
• Written rapport of project (1/4)
• Writtn exam (1/4)

Supervision
Office hours Yes
Assistant Yes
Forum Yes

Resources
Bibliography
Computational Modeling in Biomechanics, 2010
Ressources en bibliothèque

• Computational Modeling in Biomechanics / Suvranu

Moodle Link

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