

BIO-687

Engineering of musculoskeletal system and rehabilitation

Aminian Kamiar, Pioletti Dominique, Terrier Alexandre, Various lecturers

Cursus	Sem.	Type
Biotechnology and Bioengineering		Obl.
Mechanics		Obl.

Language of teaching	English
Credits	3
Session	
Exam	Multiple
Workload	90h
Hours	42
Courses	28
TP	14
Number of positions	12

Frequency

Every 2 years

Remark

Next time Fall 2020

Summary

This course presents today research questions and methods associated to the musculoskeletal system, its pathologies, and treatment. In parallel to lectures and hands-on lab, the students will acquire this knowledge by doing a mini-project.

Content

The course is divided in 5 modules given in the format of lectures, plus one morning in the hospital to attend a surgery. The first module includes theoretical background on biomechanics of musculoskeletal system and the analysis of movement. The next 3 modules are related to a specific joint. The last module is devoted to tissue engineering. Lectures from both engineering and medical points of view will be presented.

- 1) General concept of musculoskeletal system biomechanics and locomotion.
 - 1.1 Introduction to biomechanics, conservation laws + constitutive equations (linear, non-linear, ...) (DP: 2 hrs)
 - 1.2 General numerical concepts (FE, μ FE, ...) (AT: 2 hrs)
 - 1.3 Kinematics and locomotion evaluation (KA: 2 hrs)
- 2) Hip/knee
 - 2.1 Knee and hip arthritis, ligament ruptures, knee/hip implant, ligament surgery (OG: 1 hr)
 - 2.2 Knee, hip, ligament modeling, patient specific model, implant design comparison (AT: 1 hr)
 - 2.3 Bone remodeling, local drug delivery (mCT & mFE) (DP: 1 hr)
 - 2.4 3D gait analysis using kinematics and spatio-temporal parameters (KA: 1 hr)
- 3) Shoulder
 - 3.1 Shoulder anatomical analysis, disease (rotator cuff tears, osteoarthritis), its surgical treatments (AF: 1 hr)
 - 3.2 CT & MRI image for modeling, FE modeling (AT: 2 hr)
 - 3.3 3D functional evaluation with functional test and long-term monitoring (KA: 2 hr)
- 4) Tissue engineering
 - 4.1 Biomechanics in tissue engineering (DP: 1 hr)
 - 4.2 Bone and cartilage tissue engineering (RM: 1 hr, DP: 1 hr)
- 5) Ankle
 - 5.1 Ankle diseases (foot flat, arthritis, tendinopathy), its treatments (XC: 1 hr)
 - 5.2 FE modeling, experimental (cadaveric) data to validate FE, revision prostheses (AT: 1 hr)
 - 5.3 3D gait analysis with ground reaction force and inverse dynamics (KA: 1 hr)

6) Possibility to attend a total joint replacement surgery (3h)

2 personnes per operation, see with MD

7) project presentation with all (3h)

Note

This course will address clinical and translational aspects of biomechanical engineering by using new technologies and methodologies. It will bring together biomechanical engineers, orthopedics surgeons and physical therapists, in order to present the state of the art in musculoskeletal system biomechanics and rehabilitation. Based on theoretical biomechanical descriptions and the underlying methodologies, the course will focus on the evaluation of joint function, the design of joint implant and the corresponding surgical techniques, the development of new bioengineering solutions, to induce bone and tissue formation, the analysis of the locomotion, the evaluation of functional performance, and the restoration of healthy movement.

The course will have a clear inter-disciplinary concept to help students understanding the translational aspect of this field, by including lectures from medical doctors, surgeons and orthopedics implant producer industries.

The course will last for one full semester and will feature a number of different activities:

- Lectures: sessions will cover engineering, medical and clinical aspects as well as discussions around various research themes. Sessions will include in-depth talks and theoretical lectures on the biomechanics, pathologies, treatment and outcome evaluation of musculoskeletal system. A Q&A discussion will follow each of these sessions.
- Hands-on labs: the course will integrate several lab sessions, which will provide hands-on experience on instrumentation and equipment covering the lecture topics.
- Hospital visits: the course will include hospital visits with the possibility to follow real orthopedic surgery and to understand the real use of techniques in hospital
- Mini-project: different subjects will be proposed and in a team of two, a mini-project including the concepts developed during the course will be performed

The evaluation will be done through an oral presentation and evaluation of the mini-project including a discussion on the topics presented during the course.

Maximum 12 participants