295125 - 295II335 - Biomechanics & Sport Technology

Coordinating unit: 295 - EEBE - Barcelona East School of Engineering
Teaching unit: 712 - EM - Department of Mechanical Engineering
737 - RMEE - Department of Strength of Materials and Structural Engineering
702 - CMEM - Department of Materials Science and Metallurgy
710 - EEL - Department of Electronic Engineering

Academic year: 2019
Degree: MASTER'S DEGREE IN INTERDISCIPLINARY AND INNOVATIVE ENGINEERING (Syllabus 2019).
(Teaching unit Optional)
ECTS credits: 6
Teaching languages: English

Teaching staff

Coordinator: Serrancolí Masferrer, Gil
Others: Garcia Vilana, Sílvia
Lobo Prat, Joan
Nescolarde Selva, Lexa
Rodríguez Rius, Daniel
Sánchez Molina, David
Serrancolí Masferrer, Gil
Casals Gelpí, Alícia

Prior skills

- Use basic analytical mechanical methods to calculate forces and moments of a mechanical system.
- Solve differential equations.
- Use pressure/deformation calculation methods by finite elements of a simple system.
- Analyze basic signals.

Degree competences to which the subject contributes

Specific:
CEMUEII-19. Develop translational applications with the aim of achieving a better understanding of physiological phenomena of clinical relevance and for the design of new applications in areas that have an impact on the health care of people. (Specific competence of the Healthcare and Biomedical Applications specialty)

General:
CGMUEII-01. Participate in technological innovation projects in multidisciplinary problems, applying mathematical, analytical, scientific, instrumental, technological and management knowledge.
CGMUEII-05. To communicate hypotheses, procedures and results to specialized and non-specialized audiences in a clear and unambiguous way, both orally and through reports and diagrams, in the context of the development of technical solutions for problems of an interdisciplinary nature.

Transversal:
05 TEQ. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.
06 URI. EFFECTIVE USE OF INFORMATION RESOURCES. Managing the acquisition, structure, analysis and display of information from the own field of specialization. Taking a critical stance with regard to the results obtained.
03 TLG. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.
Teaching methodology

This subject will combine theory sessions and one practical session per chapter. In theory sessions, the student will acquire the contents of each chapter, and in practical sessions, he/she will be able to develop his/her skills using real biomechanical data.

Learning objectives of the subject

• Learn the basic methods to calculate joint forces and moments of a biomechanical system during movement (macroscale analysis).
• Identify the boundary conditions of a microscale analysis (obtained from the macroscale analysis), mainly calculation of pressures and deformations using finite element methods. Familiarize with the main parameters of a constitutive tissue model.
• Learn the causes of most frequent muscle injuries and classify them using medical images.
• Identify the causes and consequences of most common neural injuries that affect the mobility of the human body. Learn the current devices to assist injured subjects with mobility impairments.

Study load

<table>
<thead>
<tr>
<th>Total learning time: 150h</th>
<th>Hours large group: 22h</th>
<th>14.67%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hours medium group: 0h</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>Hours small group: 22h</td>
<td>14.67%</td>
</tr>
<tr>
<td></td>
<td>Guided activities: 4h</td>
<td>2.67%</td>
</tr>
<tr>
<td></td>
<td>Self study: 102h</td>
<td>68.00%</td>
</tr>
</tbody>
</table>
## Introduction

**Learning time:** 6h  
Theory classes: 2h  
Self study : 4h  

### Description:
- Introduction to the subject (macroscale to microscale)  
- Review of the macro and microscale modelling of human body  

### Specific objectives:
- Identify active and passive structures of the human body responsible of the movement to build the biomechanics system model.  
- Identify the current motion capture systems that can be used to capture the human body movement.  

## Human body dynamics

**Learning time:** 30h  
Theory classes: 8h  
Laboratory classes: 4h  
Self study : 18h  

### Description:
- Calculation of kinematics from motion capture data  
- Calculation of joint moments  
- Calculation of muscle and joint contact forces  

### Related activities:
Practical session 1. Motion capture and inverse kinematics and dynamics analyses.  

### Specific objectives:
- The student will learn how to model human body from a macro-scale point of view  
- Describe and perform inverse kinematics and dynamics analyses using the biomechanics open-source software OpenSim.  
- Estimate muscle forces for a given movement.
<table>
<thead>
<tr>
<th><strong>Neuromusculoskeletal Disorders and</strong>&lt;br&gt;<strong>Assistive/Rehabilitation Technology</strong></th>
<th><strong>Learning time:</strong> 18h  &lt;br&gt;<strong>Theory classes:</strong> 4h  &lt;br&gt;<strong>Laboratory classes:</strong> 2h  &lt;br&gt;<strong>Self study:</strong> 12h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong>&lt;br&gt;This section of the course builds upon the concepts on biomechanics and human movement control acquired in section 1-2 and gives and overview to the main neuromusculoskeletal disorders and the technology that is being developed to provide assistance or rehabilitation to people suffering these disorders.</td>
<td></td>
</tr>
<tr>
<td><strong>Related activities:</strong>&lt;br&gt;Practical session 2. Control of biomechatronic systems for rehabilitation</td>
<td></td>
</tr>
<tr>
<td><strong>Specific objectives:</strong>&lt;br&gt;1. Describe the underlying cause of the most common neuromusculoskeletal disorders.&lt;br&gt;2. Analyze how different types of control interfaces, mechanical architectures, actuators and sensors are used to support impaired human motor functions.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Muscle Assessments: Sports Injuries</strong></th>
<th><strong>Learning time:</strong> 18h  &lt;br&gt;<strong>Theory classes:</strong> 4h  &lt;br&gt;<strong>Laboratory classes:</strong> 2h  &lt;br&gt;<strong>Self study:</strong> 12h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong>&lt;br&gt;Brief description of the anatomy and physiology of the large muscle groups of the lower limbs. Muscle injuries of the lower limbs. Classification of muscle injuries. Diagnostic imaging techniques: ultrasound (US) and magnetic resonance imaging (MRI). Localized bioimpedance measurements (L-BIA).</td>
<td></td>
</tr>
<tr>
<td><strong>Related activities:</strong>&lt;br&gt;Practical session 3. Assessment of muscle injuries by diagnostic imaging techniques (US and MRI) and by localized bioimpedance measurement.</td>
<td></td>
</tr>
<tr>
<td><strong>Specific objectives:</strong>&lt;br&gt;1. Learn different types of muscle injury classification taking into account anatomical location, mechanism of injury, presence of &quot;gap&quot;.&lt;br&gt;2. Learn different imaging techniques that are used in clinical diagnosis of muscle injuries; as well as to quantify the degree of muscle injury.</td>
<td></td>
</tr>
</tbody>
</table>
### Tissue Characterization and Constitutive Models

<table>
<thead>
<tr>
<th>Description:</th>
<th>Learning time: 30h</th>
</tr>
</thead>
</table>
| • Introduction to the constitutive models.  
  • Introduction to the material anisotropy, viscoelasticity, and damage modelling, etc.  
  • Explain and perform an experimental design to adjust parameters of a constitutive model. | Theory classes: 8h  
Laboratory classes: 4h  
Self study : 18h |
| **Related activities:** |  |
| Practical session 4. Analysis of a flexion test with animal tissue. |  |
| **Specific objectives:** |  |
| • Comprehend how to apply the mechanical theories of continuous medium to develop a constitutive model for biological tissues.  
  • Learn the main phenomena of mechanical behaviour of tissues: anisotropy, viscoelasticity, fibres degeneration, etc.  
  • Learn how to design a set of specific experiments to adjust and calibrate parameter values of a specific constitutive model. |  |

### FEM applied to biomechanics

<table>
<thead>
<tr>
<th>Description:</th>
<th>Learning time: 18h</th>
</tr>
</thead>
</table>
| This unit will introduce the student to the use of simulation by finite element methods (FEM) applied to biomechanics:  
  • Introduction to FEM in Biomechanics.  
  • Use of constitutive models and microscale information.  
  • Simulation by FEM of tension and deformation states of tissues.  
  • Applications | Theory classes: 4h  
Laboratory classes: 2h  
Self study : 12h |
| **Related activities:** |  |
| Practical session 5 (use of FEBio in Biomechanics) |  |
| **Specific objectives:** |  |
| Describe and perform a simulation by FEM of a hard tissue |  |

### Qualification system

| Practical session reports (30%)  
Final exam of practical sessions (30%)  
Final exam of the subject (40%) |  |
|-------------------------------|---|
Bibliography

Others resources:

**Computer material**

**OpenSim**

Biomechanics software OpenSim. Link: https://simtk.org/frs/?group_id=91

**FEBio**

Biomechanics software of finite elements applied to biomechanics. Link: https://febio.org/