1. **Course description**

This course unit deals with the biomechanical analysis of human movement based on anatomical concepts and mechanical laws of motion. On completion of the course unit, students should be able to:

- Develop biomechanical models of the human musculoskeletal system based on anatomical concepts and mechanical laws of motion.
- Analyze kinematic, dynamic and energetic aspects of human movement through these models.

2. **Course objectives**

**Concerning knowledge**
In this course unit students will learn tools for the biomechanical analysis of human movement. This analysis will be based on mathematical models taking into account the body anthropometry.

**Concerning abilities and skills**
Students will develop skills and competences allowing them to:

- Apply kinematic and kinetic descriptors to human movements.
- Apply mechanical laws and principles to anatomical structures.
- Describe how musculoskeletal structures influence human movement.
- Analyze human performance from measured data.

**Concerning attitudes, values and norms**
This course unit will help students to develop in a number of areas, including effort, discipline, collaboration and teamwork, analysis of multidisciplinary problems, spoken and written communication, and preparation of multimedia material.

3. **Prerequisites**

Students should have completed a basic course on Fundamental Mechanics, and have an English level allowing them to understand textbooks and oral presentations in that language.
4. Course outline

Introduction

Section I: Kinematics
- Planar configuration (2D)
  - Reference frames, coordinates system
  - Position and trajectory of a single point
  - Kinematical chains: angles conventions, Independent Coordinates (IC), geometrical constraints
  - Measurement and filtering
- Planar motion (2D)
  - Velocity and acceleration of a point
  - Rotation of a segment, Instantaneous Center of Rotation (ICR)
  - Rigid body kinematics
  - Kinematical chain: Degrees of Freedom (DOF), kinematical constraints

Section II: Vectorial dynamics
- Particle dynamics: Newton’s laws
- Rigid body dynamics
  - Linear Momentum Theorem (LMT)
  - Angular Momentum Theorem (AMT)
- Anthropometry
- Forces
  - Classification
  - Torsor of forces
  - Formulation: gravitation, friction
  - Characterization: joints torsor, muscles torsor
  - Measurement of ground forces
- Formulation of musculoskeletal forces

Section III: Biomechanical energetics
- System of particles
  - Power and energy balances
  - Kinetic and potential energy
- Rigid bodies
  - Power and energy balances
  - Kinetic and potential energy
- Energy flow in human body
  - Generation, absorption, transmission
  - Metabolic cost, efficiency

**Estimated learning time**

<table>
<thead>
<tr>
<th>Factor hours/ECTS</th>
<th>30</th>
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<tbody>
<tr>
<td>Distance or on-line activity</td>
<td>0</td>
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<tr>
<td>Self-learning activity</td>
<td>45</td>
</tr>
<tr>
<td>On-campus activity</td>
<td>30</td>
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<tr>
<td><strong>Total number of hours</strong></td>
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</tr>
<tr>
<td><strong>ECTS credits</strong></td>
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</table>
5. **Teaching methods and general organization**

The course unit has a credit weighting of 2,5 ECTS distributed as follows:

**Theory:**
The theory credits will be taught through lectures introducing basic theoretical aspects and lab sessions. Additional audiovisual materials will be made available via the virtual campus (ATENEA).

**Seminars + Assignments:**
The course unit may include a seminar led by a researcher in the field of biomechanics, which will consist of a presentation followed by a question and answer session with students. The lecturers will propose assignments through the virtual campus (ATENEA) along the course. Deadlines will be defined for the submission of the corresponding written resolution. Assignments not delivered in time will be disregarded.

6. **Evaluation procedure**

Global course grade will be based on the following partial grades (all of them out of 10 points):

- **NL** = Lab reports,
- **NA** = Written assignments,
- **NF** = Final written exam,

\[
\text{Global grade} = 0.2 \times \text{NL} + 0.3 \times \text{NA} + 0.5 \times \text{NF}
\]

7. **Bibliography**

**Basic bibliography:**

**Complementary bibliography:**
### 8. Lecture schedule

<table>
<thead>
<tr>
<th>Week</th>
<th>Day</th>
<th>Date</th>
<th>Classroom</th>
<th>General topic</th>
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<tr>
<td>1</td>
<td>Tuesday, 15:00-17:00</td>
<td>Feb. 9, 2016</td>
<td>Room 6.22 ETSEIB</td>
<td>Introduction. Planar configuration (2D): point. Gait Cycle.</td>
</tr>
<tr>
<td>2</td>
<td>Tuesday, 15:00-17:00</td>
<td>Feb. 16, 2016</td>
<td>Room 5.3 ETSEIB</td>
<td>Cancelled</td>
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<td>3</td>
<td>Tuesday, 15:00-17:00</td>
<td>Feb. 23, 2016</td>
<td>Room 5.3 ETSEIB</td>
<td>Kinematics of body points. Numerical derivation and filtering. (Lab1)</td>
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<td>4</td>
<td>Tuesday, 15:00-17:00</td>
<td>Mar. 1, 2016</td>
<td>Room 5.3 ETSEIB</td>
<td>Kinematics of body chains. Absolute and joint angles. (Lab2)</td>
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<td>5</td>
<td>Tuesday, 15:00-17:00</td>
<td>Mar. 8, 2016</td>
<td>Room 5.3 ETSEIB</td>
<td>Kinematics of body segments. Rigid body kinematics. (Lab3)</td>
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<td>6</td>
<td>Tuesday, 15:00-17:00</td>
<td>Mar. 15, 2016</td>
<td>Room 6.22 ETSEIB</td>
<td>Kinematics. Exercises and examples.</td>
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<td></td>
<td><strong>EASTER HOLIDAYS</strong></td>
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<td></td>
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<td>7</td>
<td>Tuesday, 15:00-17:00</td>
<td>Mar. 29, 2016</td>
<td>Room 6.22 ETSEIB</td>
<td>Vectorial dynamics. Inverse and forward dynamic analyses. LMT and AMT.</td>
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<td>8</td>
<td>Tuesday, 15:00-17:00</td>
<td>Apr. 5, 2016</td>
<td>Room 6.22 ETSEIB</td>
<td>Anthropometry. Tensor of inertia and Steiner’s Theorem. Joint torsor.</td>
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<td>9</td>
<td>Tuesday, 15:00-17:00</td>
<td>Apr. 12, 2016</td>
<td>Room 6.22 ETSEIB</td>
<td>Analytical and numerical example: Weight lifting problem.</td>
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<td>10</td>
<td>Tuesday, 15:00-17:00</td>
<td>Apr. 19, 2016</td>
<td>Room 6.22 ETSEIB</td>
<td>Musculoskeletal forces: Hill and Huxley models.</td>
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<td>11</td>
<td>Tuesday, 15:00-17:00</td>
<td>Apr. 26, 2016</td>
<td>Room 6.22 ETSEIB</td>
<td>Dynamics. Exercises and examples.</td>
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<td>12</td>
<td>Tuesday, 15:00-17:00</td>
<td>May 3, 2016</td>
<td>Room 6.22 ETSEIB</td>
<td>Mechanical energy balance. Kinetic energy and potential energy.</td>
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<td>13</td>
<td><strong>Tuesday, 15:00-17:00</strong></td>
<td><strong>May 10, 2016</strong></td>
<td><strong>UPC Biomech. Lab</strong></td>
<td><strong>UPC Biomechanics Lab. Measurements and projects.</strong></td>
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<td>14</td>
<td>Tuesday, 15:00-17:00</td>
<td>May 17, 2016</td>
<td>Room 6.22 ETSEIB</td>
<td>Energy flow in the human body. Biomechanical energetics and Thermodynamics. Metabolic cost.</td>
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<tr>
<td>15</td>
<td><strong>Wednesday, 14:30-16:30</strong></td>
<td><strong>May 25, 2016</strong></td>
<td><strong>Room B.6 ETSEIB</strong></td>
<td><strong>Final exam</strong></td>
</tr>
</tbody>
</table>

### 9. Teaching team

**Course coordinator and lecturer**

![Image][1]

Josep Maria FONT LLAGUNES

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