Biomechanics I (BMCI)

1 General information

Academic year: 2013-2014

Duration: 2nd and 3rd trimesters

Degree: Bachelor's degree in Biomedical Engineering

Number of ECTS credits: 6

Teachers: Mario Ceresa, PhD, Ing. (lectures, seminars), Nerea Mangado Ing. (labs)

2 Course Description

Biomechanics is a multi-disciplinary field related to the application of physics in mechanical aspects of biological systems and in particular to human body. This is a very important field for all biomedical engineering students.

The aim of this course is threefold: first, we want to give the student a solid foundation in mechanical physics and behavior of muscle fibers, second, an introductory theoretical description of static equilibrium and deformation of continuous mediums, third, to teach how to apply these concepts in practical problems with and without the aid of the computer.

3 Structure

The course's material is structured in theoretical, seminar and practical classes. Theoretical classes present the fundamental topics of the course. During seminar classes numerical problems are solved and additional material related to special aspects of biomechanics is presented. During practical classes, students learn to solve more complex problems using computational resources.

3.1 Theory classes (26 h)

Block 1. Introduction

- Presentation of the course
- Introduction to cellular and muscular biomechanics
- Standard units
- Physical quantities
- Coordinate systems

- Vector calculus

Block 2. Motion in one and two dimensions

- Displacement, velocity and time
- Acceleration
- Kinematics
- Angular velocity and acceleration

Block 3. Forces and Newton's laws of motion

- Newton's laws of motion
- Normal and contact forces
- Tension in a row
- Frictional forces

Block 4. Work and energy

- Conservation laws
- Mechanical advantage
- Hooke's law

Block 5. Linear momentum

- Impact and linear momentum
- Conservation laws
- Elastic collisions

Block 6. Torque and angular momentum

- Center of mass
- Torque
- Angular momentum
- Conservation laws

Block 7. Static equilibrium

- Conditions for static equilibrium
- Free body diagram

Block 8. Mechanical behavior of fibers

- Skeleton muscle
- Elastic fibers in one and two dimensions
- Viscous behavior
- Viscous-elastic behavior: the Maxwell and Kelvin-Voigt model

Block 9. One-dimensional continuous elastic medium

- Equilibrium in slender structures
- Stress and strain
- Deformation of an in-homogeneous bar

3.2 Seminar classes (14 h)

- **Seminar 1 (2h):** Additional materials or problems on Block 2
- **Seminar 2 (2h):** Additional materials or problems on Block 3
- **Seminar 3 (2h):** Additional materials or problems on Block 4, 5
- **Seminar 4 (2h):** Additional materials or problems on Block 6, 7
- **Seminar 5 (2h):** Additional materials or problems on Block 8
- **Seminar 6 (2h):** Additional materials or problems on Block 9

3.3 Practical classes (12 h)

- **Practice 1 (2h)**

  title: *Introduction to MATLAB's use in Biomechanics*

  Description. In this practice a simple MATLAB model of the elbow is presented and students are guided during the characterization of its kinematic properties.

- **Practice 2 (2h)**

  title: *Kinematic of jumping and push-off*

  Description. We analyze the kinematic of jumping and incorporate anthropometric details in our model.

- **Practice 3 (2h)**

  title: *Kinematic of the center of mass of an articulated body*

  Description. We extend the example used in the previous sessions to characterize the kinematic of the center of mass of the articulated body segments.

- **Practice 4 (2h)**

  title: *Terrestrial locomotion: an energetic perspective*

  Description. We re-consider a familiar example of terrestrial locomotion using the principles of work and conservation of energy.

- **Practice 5 (2h)**

  title: *Elasticity of tissues*

  Description. We present a computational solution to the problem of 2D deformation of slender structures.

- **Practice 6 (2h)**

  title: *Example modeling of muscoloskeletal system using OpenSim*

  Description. We present a widely-used Open Source tool in Biomechanics: OpenSim. In this session we learn how to use it to model and explore the muscoloskeletal system.

4 Evaluation

Evaluation of the course is on all the presented material during theoretical, seminar and practical classes. The final mark is calculated as follows:

- Deliverables and reports for the practical sessions: 20% of the final mark. Please note that assistance to the practical classes is mandatory and not recoverable.
- There will be a partial written examination in the middle of the course specific to the topics covered in blocks 1-5. This exam will weight 30% of the final mark.
- A final written examination on all the topics covered during the course: 50% of the final mark.

In order to pass the course you need to:

- Attend to practical classes and deliver all requested reports.
- Score a minimum of 5 in all written examinations.
- Score a minimum of 5 in the global mark.

5 Suggested material

1. Paul A. Tipler, Gene Mosca, "Física per a la ciència i la tecnologia", Reverté, 2010
2. Lewin, Walter. 8.01 Physics I: Classical Mechanics, Fall 1999. (MIT OpenCourseWare: Massachusetts Institute of Technology), License: Creative Commons BY-NC-SA
3. S. Burbano, E. Burbano, C. Gracia Muñoz, "Problemas de física", Tébar, DL 2004
4. C. Oomens, M. Brekelmans and F. Baaijens, "*Biomechanics: concepts and computations*", Cambridge University Press, 2009

5. C. Ross Ethier, C. A. Simmons, "*Introductory biomechanics*", Cambridge University Press, 2007

6. J.L. Meriam and L.G. Kraige, "Statics", John Wiley and Sons, New York, 1987.