Universidad Zaragoza

Academic Year/course: 2022/23

69710 - Biomechanical modeling of the cardiovascular system

Syllabus Information

Academic Year: 2022/23
Subject: 69710 - Biomechanical modeling of the cardiovascular system
Faculty / School: 110 - Escuela de Ingeniería y Arquitectura
Degree: 633 - Master's Degree in Biomedical Engineering
ECTS: 3.0
Year:
Semester: Second semester
Subject Type: Optional
Module:

1. General information

1.1. Aims of the course

The objective of the course Biomechanical Modeling of the Cardiovascular System is to provide the student with the necessary skills to create simple models to reproduce the main characteristics of the cardiovascular system. The course focuses on providing the student with a series of basic tools in computational simulation to reproduce the functional behavior of different components of the system, such as blood vessels, heart or blood flow. Models capable of simulating the main physiological conditions of organs or tissues will be presented, as well as some of the most widespread pathologies in this field. Finally, some situations of clinical interest will be presented, such as the modeling of tissue interaction with prostheses or intravascular devices.

SDG Goals:

- Goal 3: Ensure healthy lives and promote well-being for all people of all ages. Target 3.4 Reduce by one-third the mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being.
- Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation. Target 9.5 Increase scientific research and upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including by fostering innovation and significantly increasing, by 2030, the number of research and development personnel per million population and public and private sector expenditures on research and development.

1.2. Context and importance of this course in the degree

The course Biomechanical Modeling of the Cardiovascular System is an elective course within the specialty in Biomechanics and Advanced Biomaterials. This specialty aims to introduce engineering tools in the biomedical context for diagnosis, prevention, therapies, device and implant design, etc. To this end, the construction of numerical models that allow mimicking the behavior of the biological tissues that make up the cardiovascular system and blood flow under different physiological or pathological conditions are of great scientific and technological interest in the context of the degree.

1.3. Recommendations to take this course

Students should have taken the following courses of the master's degree: Fundamentals of Anatomy, Physiology, Pathology and Therapeutics; Biomechanics and Biomaterials and Biostatistics and Numerical Methods.

2. Learning goals

2.1. Competences

Possess and understand knowledge that provides a basis or opportunity for originality in the development and/or application of ideas, often in a research context (CB.6).

That students know how to apply acquired knowledge and problem-solving skills in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their area of study (CB.7).

That students are able to integrate knowledge and face the complexity of making judgments based on information that, being incomplete or limited, includes reflections on the social and ethical responsibilities linked to the application of their knowledge and judgments (CB.8).

That students know how to communicate their conclusions and the ultimate knowledge and reasons that support them to specialized and non-specialized audiences in a clear and unambiguous way (CB.9).

That students possess the learning skills that will enable them to continue studying in a way that will be largely self-directed or autonomous (CB.10).

To possess the aptitudes, skills and method necessary to carry out a multidisciplinary research and/or development work in any area of Biomedical Engineering (CG.1).

To be able to use the techniques, skills and tools of engineering necessary for the resolution of problems in the biomedical and biological field (CG.2).

To be able to understand and critically evaluate scientific publications in the field of Biomedical Engineering (CG.3).

To be able to learn continuously and develop autonomous learning strategies (CG.4).

Be able to manage and use bibliography, documentation, legislation, databases, software and hardware specific to biomedical engineering (CG.5).

Be able to analyze, design and evaluate solutions to problems in the biomedical field through advanced knowledge and technologies in biomechanics, biomaterials and tissue engineering (CO.3).

2.2. Learning goals

To know the main characteristics that define the mechanical behavior of the tissues of the cardiovascular system.

To identify the mathematical models of behavior (elastic, hyperelastic, inelastic, etc.) that best reproduce the properties of each type of tissue (heart, arteries and veins), as well as the behavior of blood.

To know how to apply numerical methodologies to model the behavior of the different biological structures that compose the cardiovascular system.

To be able to apply numerical methodologies to analyze and model blood flow and its interaction with the vessels and the heart.

Know how to apply numerical methodologies to analyze and study the interaction of the cardiovascular system with medical devices and implants.

2.3. Importance of learning goals

Nowadays, computational models have become increasingly important. Together with the development of analytical models and experimental studies. They have allowed important advances in different fields, such as a better understanding of numerous cardiovascular pathologies, improvements in their therapies or treatment, new detection methods or the development of new devices and prostheses, among many others. The skills acquired by the student in this course will allow him/her to approach this type of approaches, and to join multidisciplinary working groups, which will allow these problems to be approached from a much more comprehensive point of view. The biomedical engineer must have a broader profile that allows to build bridges between two traditionally somewhat distant fields such as engineering and biomedical sciences.

3. Assessment (1st and 2nd call)

3.1. Assessment tasks (description of tasks, marking system and assessment criteria)

In order to allow the **continuous evaluation** of the student who is studying the course as it is taught, the following activities are proposed with their corresponding weighting in the final grade and minimum grade for averaging

E1: Final exam (40%).

Exam with a score from 0 to 10 points. The test will consist of several theoretical-practical questions. There will be a final exams on the dates and times determined by the School. The student must obtain a minimum total score of 4 points out of 10 to average with the rest of the evaluation activities, in case of being lower the global evaluation of the whole subject will be failed.

E2: Personal work (30%).

Scoring from 0 to 10 points. In the evaluation of the tutored works proposed throughout the two-month period, both the memory presented and the suitability and originality of the proposed solution, as well as the oral presentation, will be taken into account. The student must obtain a minimum total score of 4 points out of 10 to average with the rest of the evaluation activities, in case of being lower the global evaluation of the whole course will be failed.

E3: Lab or computer practices (30%).

Scoring from 0 to 10 points. The evaluation of the practicals will be carried out through the reports presented after the practicals, as well as the work done in the laboratory or computer room. The student must obtain a minimum total score of 4 points out of 10 to average with the rest of the evaluation activities, in case of being lower the global evaluation of the whole subject will be failed.

In the case of students who choice the **global evaluation**, the final exam will include questions of the theoretical part with a value of 70% and of the practices whose final value will be 30%.

4. Methodology, learning tasks, syllabus and resources

4.1. Methodological overview

The methodology followed in this course is oriented towards achievement of the learning objectives. It promotes the continuous development of the matter and the relationship between the different parts of this course. A wide range of teaching and learning tasks are implemented, such as lectures where the main contents are presented and discussed; practice sessions where different activities related to the main contents would be planned practice tasks, homework, and specific research activities.

Students are expected to participate actively in the class throughout the semester.

4.2. Learning tasks

The course includes the following learning tasks:

- **A01** Lectures (20 hours). The main course contents are presented and student participation is encouraged.
- **A03** Practice sessions (8 hours). Different practice sessions are carried out. Notes for each practice session where the different activities are planned will be available before the session. In the following days after the practice session, the student should hand in a report of the corresponding lab session.
- **A05** Assignments. Different activities/tasks are proposed related to theoretical contents or the research in this field.
- **A06** Tutorials. Students may ask any questions they might have about unclear contents of the course.
- **A08** Assessment (4 hours). The student will take an exam and submit several reports derived from the computer lab sessions and the assignments.
- Autonomous work and study.

Activities A05 Assignments, A08 Assessment and autonomous work will account for 48 hours.

4.3. Syllabus

The course will address the following topics:

1. Introduction
2. Composition, structure and functionality of the tissues of the cardiovascular system.
3. Elastic behaviour models for cardiovascular tissue.
4. Inelastic behaviour models for cardiovascular tissue.
5. Modelling of the blood flow.
6. Modelling of adaptive and degenerative processes in the cardiovascular pathologies.
7. Interaction of intravascular devices and prostheses in the cardiovascular system.

4.4. Course planning and calendar

Further information concerning the timetable, classroom, office hours, assessment dates and other details regarding this course, will be provided on the first day of class or please refer to the EINA website.

4.5. Bibliography and recommended resources

http://psfunizar10.unizar.es/br13/egAsignaturas.php?codigo=69310&Identificador=4985