UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Modeling and Simulation II

2425-4-H4102D089-H4102D097M

Aims

Blood flow behavior in the cardiovascular system and elastic response of the vessel walls can be successfully modeled by means of the continuum mechanics approach, combining computational fluid dynamics and computational mechanics. Accordingly, computational modeling tools are an effective means to study pathologies of the cardiovascular system and have the potential to assist surgical planning by enabling the prediction of the outcomes of surgery. Pathologies and surgical interventions that deserve to be investigated are for example atherosclerosis, cerebral and abdominal aneurysms, arteriovenous fistula creation in hemodialysis patients and transcatheter aortic valve replacement, just to name a few.
The course has the following goals:

1. Develop the ability to guess the main flow features by evaluating the relevant non-dimensional groups, that is without modeling and simulation.
2. Understand the capabilities of modeling and simulation, that is the ability to quantify the quantities of interest that might be relevant to study a pathology or predict outcome of surgery.

Contents

First half of the course. Dimensional analysis and similarity applied to the cardiovascular system: guessing the main flow features by evaluating the relevant non-dimensional groups.
Second half of the course. Computational modeling tools applied to hemodynamics: quantifying relevant quantities of interest by simulating the flow behavior.
The course hopes to stimulate a discussion regarding the relevance of computational modeling tools, the meaning of patient-specific hemodynamics and the value of computational hemodynamics as a research tool.

Detailed program

1. Dimensional analysis and similarity: the relevance of Reynolds and Womersley numbers in the cardiovascular system.

2. The role of pulsatility, laminar and turbulent flows in the cardiovascular system.

3. The continuum mechanics approach: Navier-Stokes equations and their physical meaning, introduction to the control volume method with emphasis on inputs and outputs of the mathematical model.

4. The cell centered finite volume method: conservation of physical properties by means of single valued flux formulations at interelement boundaries.

5. Fundamental concepts in computational modeling: accuracy of numerical solutions, convergence to the exact solution, boundary conditions, computational domain representation, relationship between the numerical solution and the real flow behavior, the concept of patient-specific hemodynamics.

6. Use of computational modeling tools: identification of the quantities of interest, importance of sensitivity analysis and uncertainty quantification, achieving clinical relevance by means of population studies and clinical studies.

Prerequisites

Students are supposed to have an interest in physical phenomena.

Teaching form

Teaching will take place through lectures. Training sessions will be organized, with the aim to teach how to use computational modeling tools and flow visualization techniques.

Textbook and teaching resource

The teaching material will be made available on the moodle platform.

Semester

First Semester

Assessment method

Learning assessment will be carried out based on questions regarding the course topics

Office hours

Contact by e-mail

Sustainable Development Goals

INDUSTRY, INNOVATION AND INFRASTRUCTURE