UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Modeling and Simulation II

2223-4-H4102D027-H4102D097M

Aims

Blood flow behavior in the cardiovascular system and elastic response of the vessel walls can be successfully modelled by means of the continuum mechanics approach, combining computational fluid dynamics and computational mechanics. Accordingly, computational modelling tools are an effective mean 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 intervertions that deserve to be investigated are for example atherosclerosis, cerebral and abdominal aneurysms, arteriovenous fistula creation in hemodialisys 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 modelling and simulation.
2. Understand the capabilities of modelling and simulation, that is the ability to quantify the quantities of interest that might be relevant to study a patology 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 modelling tools applied to hemodynamics: quantifying relevant quantities of interest by simulating the flow behaviour.
The course hopes to stimulate a discussion regarding the relevance of computational modelling tools, the meaning of patient-specific hemodynamics and the value of computional hemodynamics as a research tool.

Detailed program

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

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

3) Example of flow visualization using the Parview software: velocity, pressure, wall shear stress, streamlines.

4) 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.

5) Fundamental concepts in computational modelling: 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 modelling 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

Basic knowledge of physics, morphology and physiology of the cardiovascular system.

Teaching form

Teaching through lectures and practical sessions demonstrating the use of software tools.

Textbook and teaching resource

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

Semester

First Semester

Assessment method

Test assessing knowledge and practical skills.

Office hours

Contact by e-mail

Sustainable Development Goals

INDUSTRY, INNOVATION AND INFRASTRUCTURE