Mathematical and Numerical Modelling of the Human Cardiovascular System.

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Timetable: 24 hrs. First lecture on February 8, 2021, 09:15. The course will be held online at: https://unipd.zoom.us/j/89301619168?pwd=ZlJnOGlGSy8vWFMrOEIwSVRLL095Zz09 or Meeting ID: 893 0161 9168 Passcode: 544118

Timetable and topics:

Prof. Alfio Quarteroni
- Feb 8, 2021 – 09:15-12:15 - Introduction: why mathematical modeling, example of clinical applications, basis of physiology
- Feb 8, 2021 – 14:15-16:15 - Introduction to computational fluid-dynamics and solid mechanics

Prof. Christian Vergara
- Feb 9, 2021 - 09.15-13.15 Fluid-structure interaction: models and numerics I
- Feb 9, 2021 - 14.15-16.15 Fluid-structure interaction: models and numerics II + Geometric Multiscale approach for the cardiovascular system I
- Feb 10, 2021 - 09.15-13.15 Geometric Multiscale approach for the cardiovascular system II + Modeling the cardiac valve dynamics

Prof. Luca Dedé
- Feb 10, 2021 - 14.15-16.15 Intro cardiaco
- Feb 10, 2021 - 16.15-17.15 Electrical activity of the heart: models and numerics (part 1)
- Feb 11, 2021 - 09.15-11.15 Electrical activity of the heart: models and numerics (part 2)
- Feb 11, 2021 - 15.15-17.15 Numerical solution of cardiac fluid-dynamics and heart integration

Course requirements:

Examination and grading:

SSD:

Aim: This course aims at introducing the foundations of mathematical and numerical models of the human cardiovascular system. We address the modeling of both the vascular circulation and the cardiac function. Regarding the vascular circulation, the focus is on the modeling of the arterial and venous systems blood dynamics, the wall mechanics and their interaction. As for the cardiac function, the modeling of the main core functionalities like electro-physiology,
active and passive mechanics, blood dynamics and valve dynamics will be considered, together with their coupling. This yields a coupled system of time-dependent, nonlinear partial differential equations of multiscale nature. The choice of accurate and stable numerical methods will be discussed, together with the proposition of efficient algebraic solvers for large-scale computation. Several applications of clinical relevance will be presented.

**Course contents:**

1. Introduction: why mathematical modeling, example of clinical applications, basis of physiology
2. Introduction to computational fluid-dynamics and solid mechanics.
3. Fluid-structure interaction: models and numerics
4. Geometric Multiscale approach for the cardiovascular system
5. Electrical activity of the heart: models and numerics
6. Electro-mechanical activity: models and numerics
7. Modeling the cardiac valve dynamics
8. Numerical solution of cardiac fluid-dynamics and heart integration

**Bibliography**