GHENT UNIVERSITY

Course Specifications

Valid in the academic year 2023-2024

Computational Bio-Fluid Mechanics (E092923)

Course size *(nominal values; actual values may depend on programme)*

Credits 6.0 **Study time 180 h**

Course offerings and teaching methods in academic year 2023-2024

A (semester 2)	English	Gent	lecture seminar
B (semester 2)	Dutch	Gent	

Lecturers in academic year 2023-2024

Debbaut, Charlotte	TW06	lecturer-in-charge
Segers, Patrick	TW06	co-lecturer

Offered in the following programmes in 2023-2024	crdts	offering
Master of Science in Biomedical Engineering	6	B
Master of Science in Biomedical Engineering	6	A

Teaching languages

English, Dutch

Keywords

Computational fluid dynamics, numerical biomechanics, hemodynamics, medical image segmentation, project work.

Position of the course

Within this course, students go step by step through the workflow to create a computational fluid dynamics model of the fluid flow (e.g. blood) through a patient-specific geometry. First, a detailed 3D model of the simulation geometry has to be created based on patient-specific medical images (MRI, CT...). Subsequently, the hemodynamics within this model geometry are computed, post-processed and analysed. We typically work with a clinically relevant patient-specific case, e.g. computing the blood flow field within the aorta of a patient with a cardiovascular pathology such as an aneurysm.
The final aim is to learn how to numerically compute and interpret the flow field in patient-specific models. This results in a set of skills and knowledge that can also be transferred to other engineering disciplines requiring computational fluid dynamics (CFD), e.g. aerospace engineering.
After introductory lectures on the course and the basics of computational fluid dynamics, the students are provided with the medical images (e.g. DICOM) of the case. The students then go through the following workflow:
(i) Learning how to perform image segmentations and prepare the simulation geometry;
(ii) Creating the computational mesh (tetrahedral, hexahedral mesh) of the flow domain;
(iii) Learning how to set up a CFD problem in appropriate software, i.e. implementation of boundary conditions, fluid properties...;
(iv) Running CFD simulations to obtain the flow field, including usage of high performance computing (HPC);
(v) Post-processing and interpretation of the results.

Contents

1 Introduction to the course (workflow to be followed, basic laws of fluid mechanics etc.)

2 Basics of computational fluid dynamics (numerical solution and discretisation methods, differences between finite volume/element/difference methods etc.)
3 Introduction of the patient-specific case and the corresponding research questions to be answered
4 Introduction to the software packages (e.g. Mimics, Ansys Workbench, SimVascular...) and software tutorial(s)
5 Medical image segmentation & analysis (e.g. morphological parameters, centerlines)
6 Mesh creation and mesh sensitivity study (requirements, element types, boundary layers etc.)
7 Setup of CFD problem with the focus on boundary conditions, solver settings, transient simulations etc., and introduction to HPC options to run CFD simulations
8 Post-processing, reporting and interpreting the resulting data

Initial competences

Fluid mechanics as taught within the courses "Transportverschijnselen" and "Biomechanics".
Students who did not take the Biomechanics course at UGent will have to follow an alternative module during the first 2 sessions of the Computational Bio-Fluid Mechanics course to provide them with the necessary background.

Final competences

1 Knowledge of and hands-on experience with medical image segmentation, mesh generation and use of dedicated software to solve a steady and transient biomedical Computational Fluid Dynamics (CFD) problem for patient-specific simulations.
2 Practical knowhow and skills on running CFD simulations using high performance computing (HPC).
3 Practical knowhow and skills on processing of CFD data, the computation of meaningful hemodynamic parameters, and the presentation and interpretation of these data.
4 Experience-based insights in the importance of mesh quality and density, the choice of boundary conditions and the user dependency on the final outcome of a CFD simulation.
5 Students acquire project management, organisational, reporting and communication skills.

Conditions for credit contract

Access to this course unit via a credit contract is determined after successful competences assessment

Conditions for exam contract

This course unit cannot be taken via an exam contract

Teaching methods

Group work, Seminar, Lecture, Independent work

Extra information on the teaching methods

The course will be organized on campus.

Learning materials and price

Lecture slides and documents
Medical images
Software packages (open source or student versions, e.g. Mimics, Ansys Workbench etc.)
Use of own laptop
Ufora

References

Course content-related study coaching

Group and individual feedback during contact sessions

Assessment moments

end-of-term and continuous assessment

Examination methods in case of periodic assessment during the first examination period

Oral assessment, Assignment

Examination methods in case of periodic assessment during the second examination period

Oral assessment, Assignment

Examination methods in case of permanent assessment

Participation, Presentation, Peer and/or self assessment, Assignment

Possibilities of retake in case of permanent assessment

examination during the second examination period is not possible

Extra information on the examination methods

Non-periodical evaluation: assessment of intermediate results of project work, (progress) presentations and peer assessment.
Periodical evaluation: assessment of report on project work and oral examination.

Calculation of the examination mark

Non-periodical evaluation (project work and progress presentations): 50% of total score.
Periodical evaluation (report and oral examination): 50% of total score.
Intermediate deadlines are used for the non-periodical evaluation. When missing deadlines, a penalty will be accounted for: one point (out of 10 points) for the non-periodical evaluation will be lost per missed deadline.
When the student obtains less than 10/20 for at least one of the components (PE or NPE) , they can no longer pass the course unit as a whole. If the total score does turn out to be a mark of ten or more out of twenty, this is reduced to the highest fail mark (9/20).