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Course list "Biological Fluid Science"

Background

Biological fluid science is an interdisciplinary field which brings together engineering, fluid dynamics, applied mathematics, biology and medicine. Application areas extend from the study of fundamental biological transport processes to animal locomotion, physiological modelling and the assistance in medical diagnostics, treatment and device development.

The functioning of all biological systems is directly linked to fluid-dynamical and thermo-physical transport phenomena. A detailed understanding of the dynamic processes involved is essential in modelling the complex interactions which lead to life, growth and decay. While an impressive knowledge base has been accumulated in modern medicine regarding organ functionalities, the equivalent engineering analysis of the same phenomena is, however, often still lacking.

The study of biological fluid dynamics has great potential to bridge these gaps between fundamental and applied questions and problems, providing consistent engineering inputs to physiological modelling, medical diagnostics and therapeutic technologies.

In order to implement a systematic engineering approach, two methodologies have proven successful. Theoretical model development and numerical simulations of the relevant fluid processes and phenomena will permit, for example, the derivation of relevant scaling parameters, the localization of critical flow conditions and the identification of dominant physico-chemical reaction processes. Experiments, on the other hand, can be established to identify and verify the mechanisms at work and to test model hypotheses in an efficient, reproducible and systematic manner.

At IFD, research is conducted into biological fluid dynamics using both modelling and experimentation, often in an integrated fashion. This joint approach has proven particularly successful in various biomedical applications. Here, the existing medical knowledge of doctors is combined with rigorous analytical models describing the underlying fluid dynamics. Computer simulations and experiments using custom-designed engineering models are then employed to further explain the observed phenomena and to develop possible diagnostic and treatment scenarios.

Study program

The course recommendations for the study profile “Biological Fluid Science” are designed to provide a broad background by merging offerings of different professorships and competence areas into a single curriculum. For example, courses in biofluid dynamics and transport processes are recommended together with others on imaging diagnostics and computational techniques. Equally eligible are selected courses from the interdisciplinary Master program in Biomedical Engineering which is offered by a group of ETH departments, University of Zürich and the University Hospital.

Many of the participating professorships are actively involved in biomedical fluid research projects and can offer corresponding thesis topics.

Modern medical engineering is inherently interdisciplinary, and also international. This means that potential employers can be found both in Switzerland and abroad. In recognition of this fact, most classes in the “Biomedical Fluid Science” profile are offered in English.

The recommended study program of this profile is summarized in the following table.

Strongly recommended core courses (22 ECTS)

Course ID	Course Title	Lecturer	HS/FS	ECTS	Schedule
151-0105-00	Imaging in Fluid Dynamics	Coletti	HS	4	Tue 10-13
227-0399-10	Physiology and Anatomy for Biomedical Engineers I	Wyss	HS	3	Tue 8-10
529-0837-01	Biomedical Engineering	Vörös et al.	HS	4	Wed 8-11
151-0170-00	Computational Multiphase Thermal Fluid Dynamics	Coletti, Dehbi, Sato	FS	4	Tue 14-17
151-0980-00	Biofluiddynamics	Obrist, Jenny	FS	4	Fri 10-13
376-1712-00	Finite Element Analysis in Biomedical Engineering	Ferguson, Helgason	FS	3	Mon 14-16

Recommended core courses (select at least 12 ECTS) or multidisciplinary courses (select at least 6 ECTS)

Course ID	Course Title	Lecturer	HS/FS	ECTS	Schedule
151-0125-00	Hydrodynamics and Cavitation	Supponen	HS	4	Mon 10-13
151-0524-00	Continuum Mechanics I	Ehret	HS	4	Fri 8-10, Wed 12-13
151-0709-00	Stochastic Methods for Engineers and Natural Scientists	Meyer-Massetti	HS	4	Wed 10-14
376-1351-00	Micro/Nanotechnology and Microfluidics for Biomedical Applications	Delamarche	HS	2	Wed 16-18
151-0212-00	Advanced CFD Methods	Jenny	FS	4	Mon 11-12 & 16-18
151-0840-00	Optimization and Machine Learning	Berisha, Mohr	FS	4	Fri 8-12
151-1906-00	Multiphase Flow	Coletti	FS	4	Mon 12-13, Tue 12-14
227-1046-00	Computer Simulations of Sensory Systems	Haslwanter	FS	3	Mon 13-16
651-4001-02	Advanced Geophysical Fluid Dynamics	Noir, Burmann	FS	2	Tue 14-16
636-0702-00	Statistical Models in Computational Biology	Beerenwinkel	FS	6	Thu 12-15

Further courses suggested by MSc tutors of IFD

Course ID	Course Title	Lecturer	HS/FS	ECTS	Schedule
151-0109-00	Turbulent Flows	Jenny	HS	4	Thu 8-10 & 13-14
151-0213-00	Fluid Dynamics with the Lattice Boltzmann Method	Karlin	HS	4	Wed 10-13
151-0293-00	Combustion and Reactive Processes in Energy and Materials Technology	Noiray, Ernst, Frouzakis	HS	4	Thu 10-12, Mon 17-18
151-0368-00	Aeroelasticity	Righi	HS	4	Thu 10-13
151-0509-00	Acoustics in Fluid Media: From Robotics to Additive Manufacturing	Ahmed	HS	4	Wed 16-19
151-0532-00	Nonlinear Dynamics and Chaos I	Haller	HS	4	Wed 10-12, Tue 16-18
151-1116-00	Introduction to Aircraft & Car Aerodynamics	Immer, Schröder	HS	4	Thu 16-19
151-0110-00	Compressible Flows	Kubik	FS	4	Wed 13-14, Thu 8-10
151-0530-00	Nonlinear Dynamics and Chaos II	Haller	FS	4	Tue 16-18, Wed 10-12
151-1115-00	Aircraft Aerodynamics and Flight Mechanics	Immer	FS	4	Thu 16-19
701-1270-00	High Performance Computing for Weather and Climate	Fuhrer	FS	3	40 hours summer break

Please note that the lists of courses will be adapted to the needs and preferences of the individual student to create his/her Master Tutor agreement.

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