Course Package

Imaging & In Vitro Diagnostics – Q2

Name module	Imaging & In Vitro Diagnostics – Q2
Educational programme	MSc Biomedical Engineering
Period	Second quartile of the first semester – Q2
Study load	15 ECTS
Coordinator	J. Huttenhuis

Imaging & In Vitro Dagnostics			
Quartile 1	**Quartile 2**	**Quartile 3**	**Quartile 4**
	Electives: choose 15 EC		
	Mathematical Methods - 191506001 (5 EC)		
	Lab on a Chip - 201600046 (5 EC)		
	***Physics of Bubbles - 193572010** (5 EC)		
	Numerical Techniques for PDE - 191551150 (5 EC)		

Required preliminary knowledge: General physics at bachelor level; Physics of Fluids, Engineering Fluid Dynamics, Transport Phenomena, or similar introductory course in fluid mechanics; Linear Algebra and Calculus.

*Please note: Higher than average workload.

Electives: choose 15 EC

191506001 - Mathematical Methods

Understanding scientific models and solving complicated engineering problems require correctly using programming and mathematical algorithms. Typical problems for Ordinary Differential Equations involve finding numerical solutions to nonlinear equations, simulating dynamical models to create characteristic time series, and assessing stability via eigenvalues. We also treat the three generic linear second-order partial differential equations (i.e. the Wave, Heat, and Laplace PDEs). We learn about finite-dimensional approximations with discretisation and Fourier analysis for these spatial systems. The goal is not only to be able to solve a given problem but also to have an intuition for the accuracy of the solution, as well as to understand how to adapt a method for a related problem. We will develop analytical insight, derive several algorithms and discuss error analysis.

In their bachelor's programme, an engineering student learns several mathematical methods through several courses on calculus and linear algebra. We start from this bachelor's level and work on three aims:

1. Refresh and enrich the student's knowledge of calculus, linear algebra, and Fourier analysis,
2. Expose the student to other areas, such as numerical analysis and mathematical algorithms, and ordinary, stochastic and partial differential equations,
3. Practising programming using Matlab or Python with an emphasis on efficiency and correctness. After this course, the student can efficiently simulate and analyse models given by differential equations. In a more complicated setting, the student will be able to choose and adopt a method for an application.

The modules are tentative and subject to change. Please check the website *regularly.*

The course consists of lectures that provide intuition for the mathematical methods. The course refers to both Matlab and Python codes, where the coverage of Python in the Reader will be expanded during the course. Sound numerics are the goal of this course, and the language is the student's choice. In the homework problems, the student deals with neuroscience and biomedical engineering applications.\

201600046 - Lab on a Chip

The Lab on a Chip course will take the student to the world of miniaturised systems used in various fields of chemistry and life sciences. A "Lab-on-a-Chip" consists of electrical, fluidic, and optical functions integrated in a microsystem, and has applications in (bio)chemical and medical fields.
The core of the lab-on-a-chip system is a microfluidic channel structure, through which nanoliter amounts of liquids with dissolved molecules are propelled by hydraulic, electrokinetic or surface forces. The fluidic structures are machined in materials like fused silica, borofloat glass, or polymers.

The course will treat all relevant aspects of such microsystems in a number of problem-based learning sessions. Microfluidic theoretical principles are treated with emphasis on the transport of liquid and dissolved molecules in microsystems and molecular separation. This is followed by an introduction in aspects of microfabrication. Electrochemical and optical detection methods are subsequently treated. Then the manipulation of cells in microfluidic systems is considered. The course finishes with a written exam and a written case study. The course is aimed at MSc students of Biomedical Engineering, Electrical Engineering, Nanotechnology, Chemical Engineering, Mechanical Engineering or Applied Physics.

193572010 - Physics of Bubbles

The Physics of Bubbles course treats the physics of single bubble and describes the behavior of multiple bubbles and bubble clouds. The course treats the forces on bubbles, the acoustics of bubbles and bubble clouds, microstreaming and jets due to bubble oscillation, cavitation and bubble collapse. The course includes lectures on the use of bubbles in medical imaging and in molecular imaging with ultrasound. Also therapeutic applications of bubbles are discussed, along with bubbles in process technology and bubble formation and bubble dynamics in microfluidic devices and nanotechnology.

191551150 - Numerical Techniques for PDE

This course concerns the numerical discretization of partial differential equations (PDEs), and the implementation and testing thereof in realistic exercises. Parabolic and hyperbolic equations encountered in mathematics, physics, and engineering are discretized with finite difference and finite volume methods. The focus lies on PDEs with a time and one spatial dimension. Accuracy and stability of the numerical discretizations are considered in theoretical analysis, and this analysis is applied in practical exercises from science and engineering. After successful completion of the course, students are able to start designing, implementing and testing discretizations of PDEs in their own field. Practical assignments and a written test need to be completed. Recent assignments concerned topics such as: a model of lava eruptions (geophysics application), linear and nonlinear shallow water equations (civil engineering application), chemical fronts of reacting species (chemistry), dynamics of bacteria and diffusion of cancer cells in the brain (medical application).