Course Package

Imaging & In Vitro Diagnostics

Name module	Imaging & In Vitro Dagnostics
Educational programme	MSc Biomedical Engineering
Period	Second block of the first semester (block 1B)
Study load	15 ECTS
Coordinator	J. Huttenhuis

Imaging & In Vitro Dagnostics			
block 1A	**block 1B**	**block 2A**	**block 2B**
	Numerical Techniques for PDE **191551150** (5 EC)		
	Mathematical Methods **191506001** (5 EC)		
	Lab on a Chip **201600046** (5 EC)		

Required preliminary knowledge: Bachelor of Calculus and Linear Algebra, Basic Analysis and Calculus (e.g., Taylor series expansion), Basic Numerical Techniques (e.g., Finite Difference approximations), and basic MATLAB implementation skills, Knowledge on Discretization of Ordinary Differential Equations is helpful, Basic knowledge about Partial Differential Equations, such as the heat equation and the advection equation, Fluid Mechanics, Physics of Fluids, Engineering Fluid Dynamics, Transport Phenomena, or similar introductory course in fluid mechanics.

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).

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

191506001 - Mathematical Methods

After this course, the student is able to

1. find roots of nonlinear functions;
2. linearize near equilibria of an ODE and classify equilibria using eigenvalues;
3. simulate deterministic and stochastic ODEs as well as perform quadrature;
4. to construct solutions of second order PDE’s equation using Fourier series or finite differences;
5. assess accuracy of results from algorithms using numerical error analysis;
6. choose or modify algorithms for new numerical problems.

The understanding of scientific models and solving complicated engineering problems requires the correct use of programming and mathematical algorithms. Typical problems involve numerical solutions of nonlinear equations, simulations of dynamical systems, stability via eigenvalues, finite-dimensional approximations of spatial systems by discretisation or Fourier analysis. The art is not just to be able to solve such problems but also to have an intuition for the accuracy of the solution. We will develop some analytical insight, derive several algorithms and discuss error analysis.

During the bachelor study, an engineering student learns several mathematical methods through a number of calculus and linear algebra courses. Starting from this bachelor level, this course has three aims:

1. Refresh and enrich the students' knowledge on calculus, linear algebra, and Fourier analysis,
2. Expose the student to other areas such as numerical analysis and mathematical algorithms, and stochastic and partial differential equations,
3. Practising programming using Matlab with emphasis on efficiency and correctness. After this course the student has the ability to 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 course consists of lectures providing an intuition to the mathematical methods. A few tutorials focus on Matlab programming. The homework problems deal with applications in neuroscience and biomedical engineering.

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.