Computational Science elective package

Computational Science	
Offered by	Department of Mathematics and Computer Science
Language	English
Primarily interesting for	All students, but most relevant for students in Applied Physics, Mechanical Engineering, Electrical Engineering, Chemical Engineering and Chemistry, Biomedical Engineering and of course Mathematics
Prerequisites	Required courses: successful completion of Calculus B or Calculus C Recommended courses: Introduction Numerical Analysis (2WN20)
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Content and composition

Introduction

Computer simulation replaces more and more real experiments. Real experiments may be too dangerous, too expensive, unethical or just technically impossible. Many disciplines have their own computational branch now: computational physics, computational chemistry, computational fluid dynamics, computational life sciences, and so on. Computational science is of vital importance for today's and tomorrow's society. It enables the prediction of: weather and climate, the effects of surgeries, the stability of tokamak plasmas, the performances of offshore wind farms, aircraft, cars, wafer steppers, micro-processors, and much more.

Independent discipline

Although computational science has spread over many disciplines, it is to be regarded as a discipline in its own right, because of the specialized skills involved, the long learning curve required, and the rapid pace of innovation, which is impossible to keep track of by non-experts and casual users. Numerical mathematics is the heart of computational science.

High-tech applications

Typical for computational science are its strong ties with high-tech companies and research institutes. Eindhoven University of Technology is located centrally in Brainport Eindhoven, breeding ground of technological innovation and home base of renowned engineering companies and research institutes. The elective package Computational Science gives a head start if you strive for a career in a high-tech industry or research institute. Moreover, it enables you to pursue further studies in the flourishing discipline computational science itself.

Course code	Course name	Level classification	Last year course is offered	Last year exam is offered
2WN30	Theory and practice of ordinary differential equations			
2WN40	Numerical linear algebra			
2WAK0	Introduction asymptotic techniques			

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Course descriptions

Theory and practice of ordinary differential equations (2WN30)
Differential equations arise everywhere in science and engineering. Examples are equations of motion for a mechanical system, conservation laws from fluid mechanics, mass balances from chemical kinetics and differential-algebraic equations describing electrical circuits. Although exact solutions are hardly available, rigorous theories do exist for many differential equations, covering topics like existence, uniqueness and stability of solutions, or conservation of invariants. An introduction will be given to some of these theories. Moreover, we will study sophisticated numerical integration methods for systems of differential equations. Specific classes of differential equations, such as Hamiltonian systems, stiff systems and differential-algebraic equations will be addressed. The lectures are combined with a practical in which numerical methods will be implemented and tested for several model problems.

Numerical linear algebra (2WN30)
Linear algebra is an important subarea of mathematics and plays a key role in formulating and solving all kinds of problems. Examples are: finding an optimal polynomial interpolation for numerical data, discretizing and numerically solving differential equations, analyzing electrical circuits, and so on. All these problems can be written in matrix-vector form. In this course we will consider ordinary systems of linear equations, over-determined systems that lead to least-squares problems and eigenvalue problems. The aim of this course is to understand the mathematics of these problems and learn to know numerical methods to accurately and efficiently solve these problems. The course is a perfect introduction to follow-up courses in computational science. Through the practical, you will get acquainted with applying the numerical methods.

Introduction asymptotic techniques (2WAK0)
A mathematical model is the explicit formulation of the way we see reality. A good mathematical model comprises only relevant effects. These are usually the (relatively) large-scale phenomena, but typical of multiscale problems is that small effects can still be important. Essential for this course is understanding and appreciation of scales and the effects of small parameters. The calculus of small parameters is called asymptotics, while perturbation methods relate to modelling with small parameters.