Offered by: Department of Mathematics and Computer Science
Language: English
Primarily interesting for: Applied Physics, Mechanical Engineering, Electrical Engineering, Chemical Engineering and Chemistry, Biomedical Engineering, Software Science, Web Science and Mathematics (for the latter 2WN30, 2WN40 and 2WAK0 only)
Prerequisites: Successful completion of Calculus B or Calculus C is a prerequisite for taking the Elective Package Computational Science.
Contact person: prof.dr.ir. Barry Koren (B.Koren@tue.nl)

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.

<table>
<thead>
<tr>
<th>Course code</th>
<th>Course name</th>
</tr>
</thead>
<tbody>
<tr>
<td>2WN50</td>
<td>Introduction computational science</td>
</tr>
<tr>
<td>2WN30</td>
<td>Theory and practice of ordinary differential equations</td>
</tr>
<tr>
<td>2WN40</td>
<td>Numerical linear algebra</td>
</tr>
<tr>
<td>2WAK0</td>
<td>Introduction asymptotic techniques</td>
</tr>
</tbody>
</table>

Precedence relationships within the package
To successfully finish the Elective Package Computational Science, three of above four courses must be successfully completed at a minimum. For all students taking the Elective Package Computational Science, a requirement is that either 2WN50 (in this package) or 2WN20 (Introduction Numerical Analysis, not in this package) is successfully finished first. The course 2WN20 is a more demanding variant of 2WN50 and is a compulsory course for second-year Mathematics students.
Course descriptions

Introduction computational science (2WN50)
Computational science is of crucial importance for engineering disciplines. The key discipline for computational science is numerical mathematics. In this course, basic numerical mathematics methods will be discussed for solving problems that cannot be solved exactly by pencil and paper. Numerical methods for interpolation, differentiation, integration and the solution of nonlinear algebraic equations will be explained and applied.

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 (2WN40)
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.

First complete
2WN50 Introduction computational science
(Q1, Level 1 Introductory, in this package)

Or
2WN30 Introduction numerical analysis
(Q1, Level 2 Deepening, not in this package, compulsory course for Applied Mathematics students)

Next study (in any order you like)
2WN30 Theory and practice of ordinary differential equations
(Q1, Level 3 Advanced)

2WN40 Numerical linear algebra
(Q3, Level 3 Advanced)

2WAK0 Introduction asymptotic techniques
(Q1, Level 3 Advanced)