Course Analysis: DN2266
Mathematical Models, Analysis and Simulation, part I, 2010/11

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Course data

- DN2266 Mathematical Models, Analysis and Simulation, part I, 7.5 credits
- Fall 2010, with written exam January 2011.
- Lecturer and course assistant: Anna-Karin Tornberg and Jon Häggblad.
- 38 hours of lectures. Office hour: 1 hour twice a week.
- ECTS: Homework including computer assignments: 3.75, written examination: 3.75.
- Students: 56 (including 5 PhD students).
- "Prestationsgrad": 57 %.
- "Examinationsgrad": 48 %.

Aims

The goals of the course are to expose the students to and give them experience of important parts of applied and computational mathematics. The scope of the course is quite broad, building a "tool box" for the students. The mathematical models considered range from equilibrium models to dynamical systems to PDEs in several variables. The numerical techniques considered covers finite difference, finite element and spectral methods. The students should get experience of numerical experiments using MATLAB, such that they will be able to analyze a range of problems both theoretically and computationally.

Changes compared to last year

- Change of lecturer from last year.
- The amount of lectures was reduced from 48 to 38 hours. This is a more common number of lectures for a Master's level course of 7,5 credits.
- Same book but new lecture notes. Structuring and composition of material altered. Less focus on e.g. the finite element method (FEM) and differential algebraic equations (DAEs). More emphasis on PDEs and Spectral methods.

- Number of homework assignments reduced from 8 to 6. Four of the six were based on homeworks from previous year with minor or moderate modifications. Two homework assignments were new.
- Reduced scores for late submission of homework. This dramatically increased the amount of homeworks submitted on time as compared to last year, with no reduction in quality of reports.

Summary of the course

Students were very active during the course. They worked on the assignments, discussed with each other, and submitted overall very good reports in time. The lectures were well attended, with an average number of 30 to 35 students. The students did not take advantage of the office hours in the way that they could, which they would have benefited from.

The course evaluation (as discussed later) shows that the students in general find the course interesting and meaningful but that they also find it rather demanding.

There were a total of 6 homework assignments. The first two assignments were small and not too difficult. The number of students that have completed each assignment (by Feb, 2011) is: 54, 50, 48, 41, 41, 33. The due date for the last assignment was scheduled in early January, before the regular exam of the course. The number of students who took the exam was 21, and an additional five students took an oral exam in December. 13 students took the re-exam in June 2011. A total of 27 students have passed the course. Currently, there are 12 students who have passed the homework part, and about 5 more with not much left to do, but that have still not passed the exam. (Due to the grading, it is possible to pass the HW module without completing all assignments). These students might now need active encouragement to actually finish the course. The number of students actually doing work on the course has improved substantially from the year before (HT 09), when 54 students signed up for the course, but where the number of students that completed the assignments were 22, 17, 19, 17, 19, 16, 18.

Examination

Written report (max two students per report) for each homework assignment, that is graded and given a score. Reduction in score for late submission was new for this year and has greatly improved the number of reports submitted on time. This had the intended effect that the students were working with the material while it was being taught.

The written exam was a theoretical exam.

Course literature

There are very different opinions about the course book. Overall, the impression is however not favorable and the book will be replaced next year. The handouts (slides) have received good feedback. They will be further improved. It is difficult to find one book that covers all the parts of the course, and also the current book had to be complemented with experts form other materials.

Course evaluation

The detailed course evaluation is attached.

The students that take this course have very different background and interests. Overall they think that their knowledge was sufficient when the course started, they find the course interesting and meaningful, but also rather demanding.

Their different interests is reflected in the way that the answers to which topic they find most interesting is distributed between different topics. The material on the Fourier transform and spectral methods is found to be one of two most interesting topics (32%), but was also ranked as the most difficult topic (55%).

Contents of course

An outline of the lectures reads as follows:

Linear Algebra, 3 lectures. Linear system of equations. Least squares and normal equations. Gaussian elimination and LU decomposition. Eigenvalues and eigenvectors. QR factorization. Singular value decomposition. Iterative methods.

Ordinary Differential Equations (ODEs), 7 lectures Modeling by differential equations. Dynamical systems. Non-dimensionalization and scaling. Linear ODEs. Phase plane and state space. Nonlinear equations, phase plane analysis by linearization. Energy considerations. Lagrange multipliers. Graph theory. Application to electrical circuits.

Partial Differential Equations (PDEs), 4 lectures Modeling (continuous in space). Advection, heat and wave equations. Conservation laws. Well-posedness. Separation of variables. Numerical discretization. Consistency, stability and convergence.

PDEs continued: The Fast Fourier Transform and Spectral methods, 3 lectures Fast fourier transform (FFT) - properties and applications. Interpolation and approximation. Aliasing. Spectral methods for the numerical solution of PDEs.

Summary, remarks and connections, 2 lectures Wrapping up the course, making connecting remarks between different modules. Example problems for exam.

Planned changes

- The book will be replaced. We want to find a book that can be a better support for the students in their studies.
- The handouts will be further improved. The number of lectures will be kept at the same level (36 hours instead of 38).

- Worksheets during lectures worked well, some better than others. More thinking is needed to find more of the simple examples that can illustrate the fundamental points.
- 88 % of the students said that the homepage of the course was good or very good. But it can certainly be improved to better aid the students in their studies. Next year, more detailed information regarding what preparations the students can do before each lecture will be posted.
- The homework assignments will be further reworked. One suggestion is to combine the two small linear algebra homeworks (HW 1 and 2) into one homework. The focus of that homework will change to already here introduce material that will appear again in later assignments.
- The graph theory and electrical circuits was deemed the most uninteresting topic by 32% of the students. The homework on this topic will be reworked, possibly even completely replaced.
- More lecture time will be devoted to Fourier analysis and spectral methods, cutting down the lecture time on e.g. graph theory and electrical circuits.
- Office hours will be more actively promoted. We would wish for a group of students to attend each office hour and lively discussions to take place. How do we get there?