Computational Electromagnetics – SSY200
Academic year 2019/2020 – Study period 3 (7.5hp)

Aim: Numerical solution of Maxwell's equations plays an increasingly important role in modern electrical engineering. Improvements, both in computer technology and numerical algorithms, make it possible to solve many electromagnetics design problems by computations, rather than the traditional way by building and testing prototypes. This holds in as diverse areas as eddy current calculations for generators, electrical machines and transformers, microwave circuits and antennas, optical components, radar scattering and electromagnetic compatibility.

The course introduces the main methods in Computational Electromagnetics: Finite Differences, Finite Elements and the Method of Moments and applies them to model problems. Applications from different areas of electromagnetics are used to illustrate the strengths and weaknesses of the methods. The course aims at enabling the student to choose appropriate methods for realistic electromagnetics problems.

Learning outcomes:

- Formulate and implement a basic computational algorithm in electromagnetics based on (i) the finite-difference scheme, (ii) the finite-element method and (iii) the boundary-element method.
- Perform basic assessment of the numerical error.
- Distinguish between different sources that contribute to the numerical error.
- Use basic extrapolation techniques.
- Choose between time, frequency or eigenvalue analysis for a given electromagnetic problem.
- Choose appropriate numerical techniques for a given application.
- Choose appropriate post-processing tools for a given application.
- Operate commercial software in an well-informed manner.
- Evaluate the computational resources required to analyze a given industrial problem.

Organization: The course is organized as lectures and exercise classes. The exercise classes are oriented towards hand-in problems (`MATLAB`) dealing with application problems.

Teachers:

- Thomas Rylander is lecturer and examiner:
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- Carl Holmberg is lecturer and teaching assistant:
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- Simon Nilsson is teaching assistant:
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Teaching schedule – study period 3: See `TimeEdit` at Chalmers Studieportal.

Literature: T. Rylander, A. Bondeson and P. Ingelström, Computational Electromagnetics (2nd edition), New York: Springer, 2013.

Examination: The examination consists of (i) five individual hand-in assignments and (ii) one individual oral examination. The grades for undergraduate students are distributed according to:

- Grade 3: Accepted compulsory hand-in assignments; and accepted oral examination on the hand-in assignments.
- Grade 4: Fulfillment of requirements for Grade 3 and, in addition, a total of 40-80 credit points collected during the course, see information below.
- Grade 5: Fulfillment of requirements for Grade 3 and, in addition, a total of 81-100 credit points collected during the course, see information below.

Graduate students need 61-100 credit points to pass the course.

The individual hand-in assignments consists of (i) compulsory tasks and (ii) additional tasks that are rewarded by credit points if correctly solved.

Each student is assessed on an individual basis during the oral examination. No aids are allowed during the oral examination. The oral examination consists of (i) four compulsory questions and (ii) four additional questions that are rewarded by credit points if correctly solved. The four compulsory questions relate to the compulsory tasks in the hand-in assignments. The four additional questions (that give credit points if correctly solved) relate to the material in the text book, which may not have been covered by the hand-in assignments. The student is given the eight questions at the very beginning of the oral exam and maximum 45 minutes to prepare the answers, where the student may use pen and paper to document the answers complemented by derivations, figures, etc. The student is then given maximum 30 minutes to present the answers to the questions.

The credit points necessary for Grade 4 and Grade 5 can be collected in two ways:

- Correctly solved additional tasks in the hand-in assignments yield credit points according to the instructions in the hand-in assignments. All tasks in the first hand-in assignment are compulsory. The maximum of credit points that can be collected from the hand-in assignments is 60.
- During the oral exam, correctly answered questions on the material in the course text book yield a maximum of 40 credit points. Four questions will be offered during the oral exam, where each correctly answered question yields a maximum of 10 credit points. The four questions are chosen from the review questions and problems in the text book.

Hand-in assignments: The hand-in assignments are solved during the computer tutorials and outside the scheduled teaching. The course involves five hand-in assignments that are solved and reported by the students on an individual basis. The hand-in assignments should be completed and corrected during the course according to the table below.

Hand-in assignment	Date for hand-in #1	Date for corrections	Date for hand-in #2
Convergence and extrapolation	2020-02-04	2020-02-11	2020-02-18
Finite-differences in frequency domain	2020-02-11	2020-02-18	2020-02-25
Finite-difference time-domain scheme	2020-02-18	2020-02-25	2020-03-03
Finite element method	2020-02-28	2020-03-06	2020-03-13
Method of Moments	2020-03-13	2020-03-20	2020-03-27

Each hand-in assignment is documented in a report and the report is handed in for correction by a teaching assistant. All hand-in assignments are uploaded to the course homepage and feedback is provided through the course homepage, which is hosted by Chalmers' learning platform. The final version of each hand-in assignment will be checked for plagiarism.