PhD Course:

Modern Methods in Industrial Mathematics

Responsible:
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Type of course:
PhD.course in mathematical modelling and applications of mathematics in industrial problems.

Workload and Credits:
Approx. two weeks full time, eight days direct and active participation. 5 ECTS

Prerequisites:
Complete MSc programme in mathematics, physics, chemistry or engineering.

Background:
The PhD course consists of three days of coursework in applied mathematics, followed by a week-long participation in the annual Study Group with Industry (ESGI).

ESGI is a workshop where academic mathematicians work on problems directly related to industry. Meetings of this nature have taken place in Great Britain for a number of years, going back to 1968 when Prof. Alan Tayler started the Oxford Study Group with Industry. The coordination of the study groups is now in the hands of the European Consortium for Mathematics in Industry (ECMI), and the name is currently European Study Group with Industry (ESGI).

ESGI runs for five work days (Monday - Friday). On the first day, the participating companies present research problems considered to be of a mathematical nature. Each such problem is taken up by a group of mathematicians who, together with the company representative, work through Thursday afternoon to find a solution. Friday is used to present in a plenary session the results from each of the problem groups.

Subsequently, each group draws up a written report and submits it to the company.

Content:
Coursework runs Thursday-Saturday prior to ESGI. Lectures alternate with exercises. Three 1-day lecture series on topics in applied mathematics will teach participants useful techniques based on concrete examples from modelling of industrial problems. Lectures are given by international experts and supported by exercises.

ESGI participation will give students first-hand experience in mathematical modelling, working with international experts in the field trying to find solutions to real-world problems. A wide range of problem types are presented to ESGI and a wide range of mathematical skills are assembled to solve them.

Coursework:
The lecture part of the PhD course may involve some prior reading and completion of a mini-project to be submitted after the lecture part, but before ESGI. During ESGI, PhD course participants

are expected to play an active role in both problem solving, presentation of solution and contribution to the final report.

Main Topics:

Bayesian Inverse Problems:

In this course, we will explore Bayesian inverse problems from a practical perspective. The aim of the course is to teach students the basic techniques for using data to learn about the structure of a model. The course will consist of an introduction to the basic concepts of Bayesian statistics and Bayesian computing. We will apply these methods to ordinary differential equation models and discuss the challenges and concepts involved in extending these techniques to more complex models.

Classical analytical mechanics:

In this 1-day overview course we will give an introduction to this classical subject. We start with a brief introduction to variational calculus; proceed from this to formulation of Lagrangian mechanics, and continue with Hamiltonian mechanics emphasizing the geometrical aspects of the two views, and working numerous examples. We will briefly mention symplectic integration.

Perturbation methods:
In this course, students will be introduced to the basic principles of perturbation methods, emphasising how these techniques can be used to simplify and analyse models that are developed in industrial mathematics. This course will cover nondimensionalisation, the concept of an asymptotic expansion, the use of regular asymptotic expansions to solve algebraic equations and differential equations, and some singular asymptotic techniques, such as boundary layer theory for differential equations. Students will come away from this course with an appreciation for the 'power of the small' and an ability to reduce a real-world model to dimensionless form and exploit small parameters to obtain simplifications of the full model.

Venue: University of Southern Denmark, Alsion 2, DK-6400 Sønderborg

Teaching term:
Weeks 33 and 34, 2013:
Course work from Thursday - Saturday in week 33/ESGI from Monday – Friday in week 34.
Time: 8:00-16:00
Room: U302

PhD course teachers and topics:
15/8: Dan Simpson (Norwegian University of Science and Technology): Bayesian Inverse Problems
16/8: Poul G. Hjorth (Danish Technical University): Classical analytical mechanics
17/8: Cameron Hall (University of Oxford): A short introduction to perturbation methods

Language: English.

Evaluation and Diplomas:
To pass the course, active participation including contribution to the final ESGI report is required. The ESGI organizers will assign 5 ECTS credits on a pass/fail basis.

Registration: Register through www.esgi.dk or by e-mail to Charlotte B. Andersen, cba@mci.sdu.dk

Registration fee:
-Free of charge for students enrolled at universities and public research institutions.
-500 euro for researchers employed at universities and public research institutions.
-1500 euro for all other participants.

Fees cover hand-outs, coffee and social events.

Registration deadline:
Monday 8 July 2013. Registration confirmation will be posted within a week after this date.

Accommodation:
There are limited rooms available as shared rooms at Danhostel Sonderborg City - http://www.sonderborgdanhostel.dk - a youth hostel just off campus. These will be offered at a discounted rate of 25 Euro for the PhD course, and will be free of charge during during the ESGI week. Alternative accommodation must be arranged by the participants themselves.