Lecturers:

Lasse Engbo Christiansen (organizer)
Department of Informatics and Mathematical Modelling

Poul Hjorth
Department of Mathematics

John Bagterp Jørgensen
Department of Informatics and Mathematical Modelling

Henrik Madsen
Department of Informatics and Mathematical Modelling

Frank Schilder
Department of Mathematics

Jens Starke (main organizer)
Department of Mathematics

Mads Peter Sørensen
Department of Mathematics

The summerschool is sponsored jointly by the departments of Mathematics & Informatics and Mathematical Modelling.

MMC Master
Master of Mathematical Modelling and Computation

Practical information:

Prerequisites
Basic mathematical knowledge including ordinary differential equations, statistics, and Matlab.
Note: For those who do not meet these prerequisites we provide additional references or material.

Workload
Approximately 100 hours in total, including work during the course period at DTU (lectures, exercises, discussions) as well as preparatory required reading before course start.

Study Material
Course material will be provided to the participants.
Preparatory reading of some of the material is required.

Language
All lectures will be given in English.

Evaluation and Diplomas
To pass the course, active participation in all activities is required; this includes successful exercise work during the course and student presentations of the exercise.
ECTS points: 5.

Registration
Please register by sending an email to summerschool@mmcmaster.dtu.dk no later than 15th of June, 2010 including a CV with a list of passed courses.

Registration fee
The course is free of charge for students. For academic and industrial participants we ask a fee of 500 euros. Travel expenses and meals are not covered.

Housing
Lodging in Student dorms will be available at a moderate cost. A limited number of scholarships to cover this are available based on motivated applications.

www.dtu.dk/mmcmaster/summerschool

MMC Master
Master of Mathematical Modelling and Computation

DTU Technical University of Denmark

One week summerschool at bachelor level

Mathematical Modelling, Nonlinear Dynamics, Stochastic and Complex Systems

Kgs. Lyngby (North of Copenhagen), Denmark

22 – 28 August, 2010

DTU Mathematics
Department of Mathematics

DTU Informatics
Department of Informatics and Mathematical Modelling

PROGRAM

This summer school will give a unique introduction to modelling with differential equations combined with data analysis. This includes both deterministic dynamical systems theory as well as stochastic systems. Lectures will cover mathematical techniques for analysing complex systems from various fields in science and engineering. All theoretical parts of the course will be accompanied with hands-on exercises using real life examples ranging from mechanics over medicine to economy.

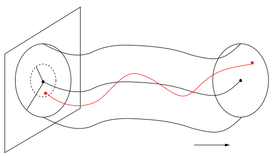
Teaching starts at the 22nd of August at 9AM sharp. The program is intense with lectures every day from 9AM until 6PM with a one hour lunch break. Every day the organisers will provide breakfast from 8:15-8:45. On Sunday the 22nd we will have a barbecue in the evening and we will offer a sight-seeing tour in Copenhagen one afternoon during the week.

Overview of topics:

Mathematical modelling, differential equations, existence and stability theory

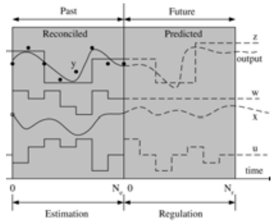
Important examples of differential equations in science and engineering, mathematical modelling, elementary solution methods, existence and uniqueness, numerical solutions, phase space, Lyapunov stability, asymptotic stability and Lyapunov functions.

Practical exercise: Numerical solution of a differential equation with the Picard iteration. Infection modelling and stability analysis of the model.



Numerical methods

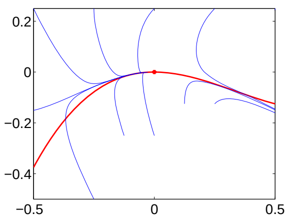
Runge-Kutta methods for non-stiff and stiff systems, error estimation, adaptive step size control, sensitivity equations, dynamic optimization, parameter estimation and optimal control.



Practical exercise: Optimal control in an artificial pancreas for Type 1 diabetics.

Theory of invariant manifolds

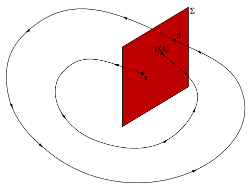
Stable manifolds, unstable manifolds, center manifolds, homoclinic orbits, heteroclinic orbits and center manifold reduction.



Practical exercise: Sensitivity of dependence on initial values in a chemical reaction.

Periodic solutions

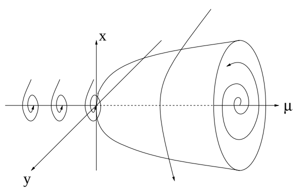
Theorem of Poincaré-Bendixon, Poincaré-sections, stability of periodic orbits and forced oscillators.



Practical exercise: Modelling a swing; analysis of the Mathieu equation.

Bifurcations and the implicit function theorem

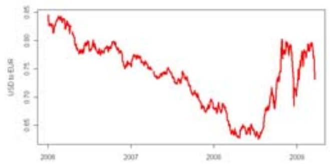
Implicit function theorem, structural stability, saddle-node bifurcation, transcritical bifurcation, pitchfork bifurcation, Hopf bifurcation and continuation techniques.



Practical exercise: Modelling an electric circuit and Van der Pol oscillator.

Time series analysis

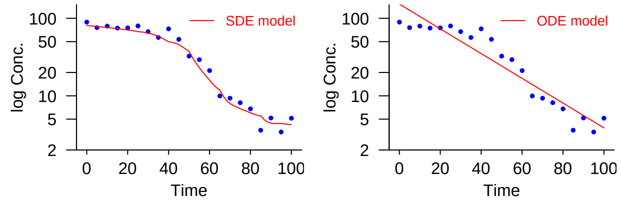
Characteristics for time series, parametric and non-parametric modelling, models for linear and non-linear time series, model identification, estimation and verification, predictions in time series.



Practical exercise: Prediction of bond prices.

Stochastic differential equations

Introduction to stochastic differential equations, Itô and Stratonovich integrals, grey-box modelling, parameter estimation and model building.



Practical exercise: Stochastic modelling of the insulin glucose relation.

Travelling waves and pattern formation

Nonlinear partial differential equations, travelling waves and soliton solutions, Korteweg de Vries equation, complex pattern formation in reaction diffusion equations, reduction to systems of ordinary differential equations, homoclinic and heteroclinic connections.

Practical exercise: Spiral waves in the Belousov-Zhabotinsky reaction.