Welcome to ADA501

Hello world

Lecturers:

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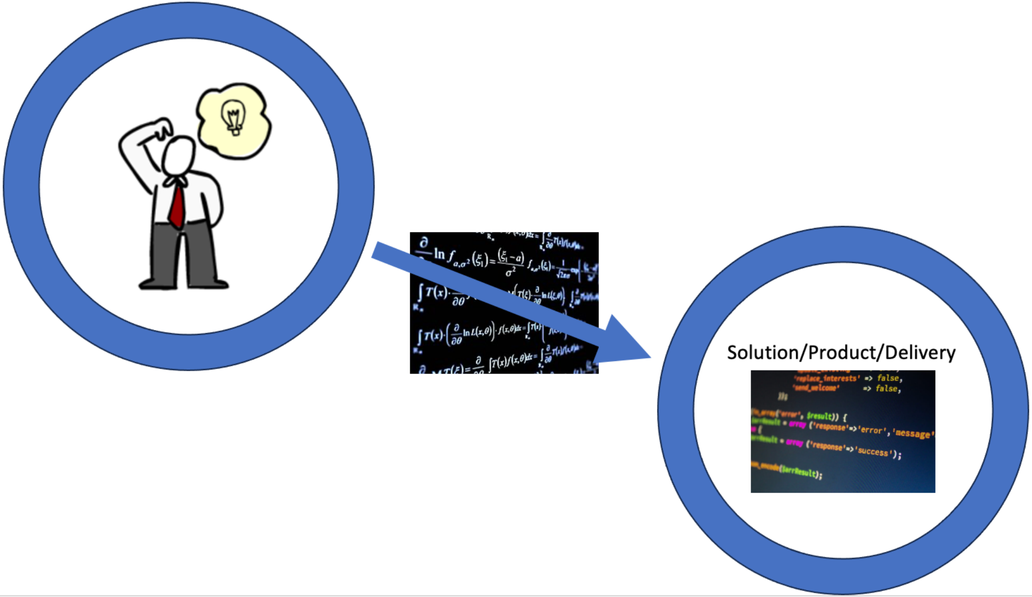
We are both sitting in Bergen: will visit Førde 4-5 times during semester.

Lectures and exercise classes:

- Mondays 12:15-14:00
- Tuesdays 8:15-12:00

Most take place in E204 (Bergen) and Linus (Førde). Check TimeEdit for details. Lectures and exercise classes are some weeks from Bergen with stream to Førde, other weeks opposite. Check canvas for details.

ADA501: Mathematical modeling and simulation



Why mathematics?

- Language with precise formulations
- Computers require precise statements
- Allows precise analysis
  - Can we say something about the problem before solving it?
  - We get a result, but is this the solution to the original problem?

In this course:

- General training in precise formulations (mathematical reasoning).
- Formulate the problem and the prior knowledge about the problem with formulas.
- Practical training: Use mathematical/numerical reasoning in programming

ADA501: Mathematical modeling and simulation

ADA501 explores the lifecycle of mathematical modeling in engineering

- What is a mathematical model?
- What do we mean with a *good* mathematical model?
- How to translate observations of phenomenon into mathematical problem?
- How to solve the resulting mathematical problem, with the help of a computer?
- How to evaluate the found solution?
- How to estimate and optimize parameters?

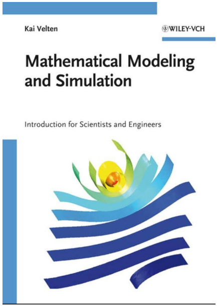
Course organized in four parts:

1. Principles of mathematical modeling
2. Regression and parameter estimation
3. Modeling with ODEs
4. Modeling with PDEs

The overall goal is to combine practical solution strategies with mathematical theory and analysis.

Curriculum

- Lecture slides and exercise sheets
- Kai Velten, Mathematical modeling and simulation (available online, link in canvas)
- Alfio Quarteroni and Paola Gervasio, A primer on mathematical modeling: Chapter 1 (pdf in canvas)
- Hans-Joachim Bungartz et al., Modeling and simulation: Chapter 2.4, Chapter 14.1-14.2 (pdf in canvas)



We will use python as main programming tool.

Course organization

- 4 h of lectures and 2 h exercises per week
- 3 obligatory assignments:
  1. Individual: Hand-in on regression (week 36)
  2. Groups: Make plan for project work (week 41)
  3. Groups: Present project work results (week 47)
- Assessment:
  - Groups: Written report on project work
  - Individual: 4 h written exam

How to succeed in this course

- Follow the lectures
- Read the course material
- Attend the exercise classes
- Make sure to do all the exercises
- Ask questions when you have any
- Discuss and collaborate with your fellow students
- Find a group to work with and do the project work

The course combines theory and practice: Hence, active participation in both lectures and exercise classes is necessary to reach learning goals.

Project work

Course contains a project work where you in groups of 3-4 students will

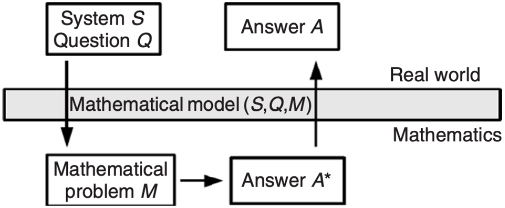
- Write a project plan containing questions you want to answer and which methods you want to apply to find the answers (oblig 2, week 41)
- Work on your project in the following weeks
- Present your project and results to your fellow students (oblig 3, week 47)
- Write and submit a report of the project (graded)

The purpose of the project work is that you apply methods and tools from the course in a new context.

Content of course

Part 1: Principles of mathematical modeling focuses on

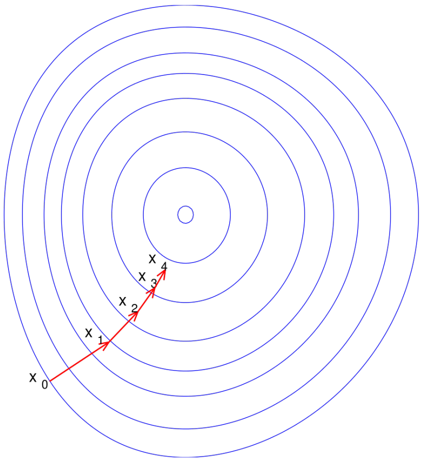
- describing general terms as (mathematical) model, different types of error, simulation, classification of mathematical models.
- guidelines for setting up a mathematical model and how to incorporate experimental data.
- what it means to validate and verify a model.



Content of course

Part 2: Regression and parameter estimation focuses on

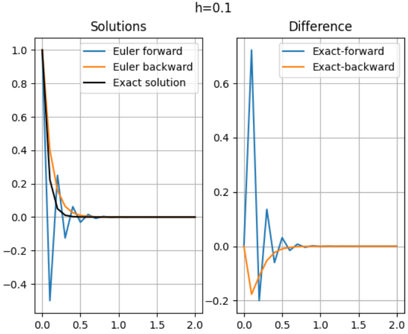
- least square formulations
- optimization methods (gradient based)
- theory behind linear and non-linear regression
- theory and analysis of convexity, regularization and over-fitting.
- numerical solvers and packages for optimization and parameter estimation.



Content of course

Part 3: Modeling with ODEs focuses on

- how to set up ODE model based on data.
- classification off, and existence and uniqueness for ODEs.
- numerical methods for solving ODEs, stability, including convergence order, error control.
- using python for solving ODEs numerically.
- parameter estimation for ODEs.
- using numerical solution to analyze original system.



Content of course

Part 4: Modeling with PDEs focuses on

- typical PDEs and what they can model.
- aspects of well-posedness for PDEs.
- numerical methods for solving PDEs: finite differences and finite element method.
- aspects of numerical error and stability for solving PDEs.
- using python for solving PDEs numerically.