Exercises for Lecture Course on Modelling and System Identification (MSI)
Albert-Ludwigs-Universität Freiburg – Winter Term 2015-2016

Exercise 0: General Information and Preliminaries

(to be returned on Oct 27, 2015, 8:00 in HS 101-00-026,
or before in building 102, 1st floor, Chair of Systems Control and Optimization)

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The lecture course on Modelling and System Identification (MSI) has as its aim to enable the students to create models that help to predict the behaviour of systems. Here, we are particularly interested in dynamic system models, i.e. systems evolving in time. With good system models, one can not only predict the future (like in weather forecasting), but also control or optimize the behaviour of a technical system, via feedback control or smart input design. Having a good model gives us access to powerful engineering tools. This course focuses on the process to obtain such models. It builds on knowledge from three fields: Systems Theory, Statistics, and Optimization. We will recall necessary concepts from these three fields on demand during the course, and ask a few basic questions on these fields already in this first sheet.

Organization of the Course

The course is based on two pillars, lectures and exercises, and accompanied by written material for self-study. Course language is English and all course communication is via the course homepage:

`http://www.syscop.de/teaching/ws2015/msi`

Lectures are on Tuesdays and Wednesdays from 8-10 and take place in HS 101-00-026 unless otherwise stated. Lectures will be recorded (voice and computer screen) and be made available to the students afterwards. **Exercises** take place Tuesdays 10-12 and Thursdays 12-14 in the MST computer pool 074-00-019. Each Tuesday an exercise sheet is distributed, and the solutions must be returned by teams of 1 to 4 people, on paper, the next Tuesday, 8:00. Exercise solutions can partially or completely be done in the computer pool.

Written material that accompanies the lecture course comprises two scripts and one book:

- The latest version of the script for this course can always be found on the course homepage.
- A script by Johan Schoukens (Vrije Universiteit Brussel, Belgium) that will be made available on the course homepage but can also be found at `http://goo.gl/xICC6r`.
- The excellent textbook *Ljung, L. (1999). System Identification: Theory for the User. Prentice Hall*. This book is available in the faculty library as a hard copy and is the main reference for this course.

Final Evaluation, Projects and Microexams

The final grade of the course is based solely on a final written exam at the end of the semester. The **final exam** is a closed book exam, only pencil, paper, and a calculator, and four single A4 pages of self-chosen formulae are allowed. In order to be eligible for the course, two criteria have to be satisfied at the end of the lecture. First, one has to have obtained at minimum 40% of the total points in the exercise sheets that are distributed each week. Second, on has to have obtained a minimum of 40% of the total points in three microexams that are written during at the start of the lecture time slots. The dates for the microexams are the following:

Microexam 1: November 17, 2015. *Microexam 2: December 15, 2015.* *Microexam 3: January 26, 2016.*

Tasks for Exercise 0

1. Write an email with (a) your name and matriculation number, (b) your field of studies, and (c) one reason why you follow the course, to the exercise tutor Robin Verschueren at `robin.verschueren@gmail.com`.
2. (statistics) Write down the probability density function $p(x)$ for a random variable X that takes values $x \in \mathbb{R}$, and which is normally distributed with mean $\mu \in \mathbb{R}$ and variance $\sigma^2 \in \mathbb{R}$. Include the normalization constant that ensures that $\int_{-\infty}^{\infty} p(x)\mathrm{d}x = 1$.
3. (optimization) Compute the minimizer of the convex function $f : (0, \infty) \to \mathbb{R}, x \mapsto f(x) = \frac{c}{x} + x$ with constant $c > 0$.
4. (systems theory) Write down the linear ordinary differential equation (ODE) that describes how the temperature $y(t)$ [K] inside a closed water bottle evolves as a function of the ambient temperature $u(t)$ [K] outside the bottle. The heat capacity of the bottle is given by C [J/K] and the total heat transfer coefficient between inside and outside the bottle by k [J/K/s], i.e. the total heat flux in [J/s] from inside to outside the bottle is given by $k \cdot (u(t) - y(t))$.

This sheet gives in total 4 points that will count as bonus points for Exercise 1