110231 Nonlinear Dynamics Lab

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1 Course description

The Nonlinear Dynamics Lab serves as a first problem-oriented introduction to nonlinear dynamics. It also provides the foundation for the theoretical lecture course 'Dynamical Systems and Control' in Fall. Nonlinear phenomena will be explored both in the laboratory and on the computer. The lab will cover real-world examples of nonlinear dynamics experiments such as nonlinear electric oscillators and pattern formation in chemical reactions, as well as some paradigmatic models of nonlinear dynamics.

Programming environments will be Scientific Python for number crunching and Mathematica for symbolic computing.

A main focus of the lab is the development of standard tools for the numerical solution of differential equations, the application of automated tools for bifurcation analysis, and continuation methods. We will also implement simple agent-based models and pseudo-spectral PDE solvers for reaction-diffusion equations.

Students wishing to hear about the theoretical foundations of some of the topics simultaneously are suggested to also take 'Applied Differential Equations and Modeling', 'Ordinary Differential Equations and Dynamical Systems' and/or 'Applied Stochastic Processes'.

Participants should be prepared to present their report and/or program code to the instructor or the entire class; this presentation may be part of the grading scheme of a particular report.

2 Structure of the lab protocols

After each "segment" (1-3 topically linked lab sessions) participants are required to submit a lab report within **five days**.

This may include a lab report as well as an independent file containing the accompanying program code with which the "Results" figures from your report have been generated. These program files should run without modification and produce the results claimed in the report. Assignments for which both a report and the code are due are indicated by 'Report' on the schedule; those for which the code file only is required are indicated by 'Code'.

Lab reports should be typeset in LaTeX and submitted electronically as a single pdf document. Your code should be appropriately commented to explain the purpose of each (non-trivial) step of your workflow. Inadequately commented code will result in deduction of a grade equivalent of 0.33; if, in addition, the code structure is not clear and transparent (e.g. misleading variable names), a further 0.33 may be deducted.

Reports should be as brief as possible (3-4 pages can sometimes be enough) without omitting essential information or discussions. You don't need to write a text book!

For every day after the deadline, a grade equivalent of 0.33 will be deducted from the grade achieved for the assignment.

For grading, code assignments will be weighted as 0.5 of assignments consisting of a lab report and code. Where both a report and code are submitted, the report has the higher importance.

One report may be omitted from grading. This covers all minor emergencies including minor illness and extracurricular activities. Further exceptions will only be made in truly extenuating and well-documented circumstances.

The structure of the lab protocol resembles that of a short scientific paper:

1. Title
2. Author
3. Abstract (briefly summarizing the goal and the result in 3-5 sentences)
4. Introduction (including a brief summary of the mathematical and scientific background, as well as the history of the problem, if applicable)
5. Methods (including details about the implementation, programming strategy; in the 'Methods' section you should describe exactly what you have been doing: which algorithm, what parameters, experimental setup, what postprocessing/visualization of the data, etc.)
6. Results
7. Conclusion (summarizing your findings and embedding them in a broader perspective)
8. References

All references, online or paper, must be included in the list of references. All help received must be acknowledged, including code segments taken from peers. There is no grade penalty for properly credited help, as long as the submission as a whole remains in essence an independent original contribution. Help or "borrowed code" without attribution is plagiarism and will be pursued according to the Code of Academic Integrity.

3 Structure of the course (subject to change)

Sessions start at 14:15 in the CLAMV Teaching Lab (in the West Hall basement).

Mon, 1. Feb. 2016	*Brief introductory session; course starts on Tuesday, Feb. 2*	
Tue, 2. Feb. 2016	Introduction I (Marcel Oliver)	
Mon, 8. Feb. 2016	Programming intro (Python)	– CODE*
Tue, 9. Feb. 2016	Programming intro (Python)	
Mon, 15. Feb. 2016	Introduction II (Marc Hütt)	
Tue, 16. Feb. 2016	Programming intro (Mathematica)	
Mon, 22. Feb. 2016	Programming intro (Mathematica)	
Tue, 23. Feb. 2016	Marcel Oliver I (ODE solvers)	
Mon, 29. Feb. 2016	Marcel Oliver II (Chua's circuit: Theory)	
Tue, 1. Mar. 2016	Marcel Oliver III (Chua's circuit: Experiment)	
Mon, 7. Mar. 2016	Marcel Oliver IV (Chua's circuit: Computational discussion)	– REPORT
Tue, 8. Mar. 2016	*Homework session*	
Mon, 14. Mar. 2016	Marc Hütt I (Stability analysis of a simple neuron model)	
Tue, 15. Mar. 2016	Marc Hütt II (Basic principles of spiral wave formation)	– CODE
Mon, 21. Mar. 2016	*Spring break*	
Tue, 22. Mar. 2016	*Spring break*	
Mon, 28. Mar. 2016	*Spring break*	
Tue, 29. Mar. 2016	Marc Hütt III (Biochemical switches and oscillators)	
Mon, 4. Apr. 2016	Marc Hütt IV (Biochemical switches and oscillators)	– REPORT
Tue, 5. Apr. 2016	*Homework session*	
Mon, 11. Apr. 2016	Tobias Preusser I (Finite difference discretization of 1D steady state diffusion)	
Tue, 12. Apr. 2016	Tobias Preusser II (Diffusion equation)	
Mon, 18. Apr. 2016	Tobias Preusser III (Simple reaction-diffusion model)	– REPORT
Tue, 19. Apr. 2016	Marcel Oliver V (Belousov-Zhabotinsky reaction: experiment)	
Mon, 25. Apr. 2016	Marcel Oliver VI (Belousov-Zhabotinsky reaction: theory)	– REPORT
Tue, 26. Apr. 2016	*Homework session*	
Mon, 2. May 2016	Marc Hütt V (Excitable dynamics in networks)	
Tue, 3. May 2016	Marc Hütt VI (Excitable dynamics in networks)	– CODE
Mon, 9. May 2016	Agostino Merico I (Daisyworld – Biological homeostasis in an idealized world)	
Tue, 10. May 2016	Agostino Merico II (Daisyworld – Biological homeostasis in an idealized world)	– REPORT

*) Deadline for this code submission is February 14.