CAS MA 226 Differential Equations Spring 2013

Instructor:

Prof. Wolfgang Walter, Institute of Scientific Computing, TU Dresden
office: Willersbau B 213, Zellescher Weg 12-14 phone: (0351) 463 33996
email: Wolfgang.Walter@tu-dresden.de

Discussion Class Instructor:

Dr. Sebastian Aland, Institute of Scientific Computing, TU Dresden
office: Willersbau B 219, Zellescher Weg 12-14 phone: (0351) 463 42377
email: Sebastian.Aland@tu-dresden.de

Course objective:

In this course we study ordinary differential equations and how to solve them. In contrast to solutions of algebraic and other types of mathematical problems, solutions of differential equations are not simply numbers, but rather *functions or families of functions* that satisfy the differential equation(s) on a certain domain, that is, for all values of the independent variable (often called t for *time*) in the domain.

Solution functions (simply called solutions from here on) may be obtained or approximated using analytic, quantitative (in particular geometric), and numerical techniques. All three approaches have their advantages, and we will learn how to choose and use the appropriate technique. We begin by deriving a few classical examples with an emphasis on the phenomena that they model. We then discuss first-order equations using all of the techniques mentioned above. Next we study first-order systems (of differential equations). Using techniques from linear algebra, we derive a systematic approach to the solution of linear systems.

Unfortunately, nonlinear systems are more difficult to investigate, but we will learn how to apply what we know about the linear case to the nonlinear case.

Often the solutions of differential equations *cannot* be written as expressions (formulas) involving arithmetic operations and elementary functions (e.g. trig, log, exp functions) only. Whenever we cannot find such closed-form solutions (whether they simply do not exist or whether we are not clever enough to find them), we might have to resort to numerical methods. For the so-called "integration" of differential equations we will study several simple numerical solution methods. The course concludes with a brief introduction to Laplace transforms.

Our overall goal is to be able to say as much as possible about the properties and the behavior of solutions of differential equations even if the solutions themselves cannot be expressed in closed-form.

IMPORTANT:

You are requested to

1. activate the computer account you received with your student ID (log in and change the password) at your earliest convenience and then
2. log into the **OPAL** system at

   `https://bildungsportal.sachsen.de/home/index_eng.html` and search for the course **TUDMATH SS2013 Differential Equations**. Please register for the course by signing up for your *assigned* Discussion Group (Monday (1) or Thursday (2)). You will then have access to all homework sets, other course material, news related to the course and a discussion forum — and we will be able to reach all of you easily by email.

Attendance at lectures and discussion sessions is mandatory!

Missing class or the discussions even with a serious written excuse more than three times will result in a failure in this course. Missing class or a discussion session without a serious written excuse more than once will also result in a failure.

Lectures:	Monday	1:00 pm – 2:30 pm	WIL C 133
	Thursday	9:20 am – 10:50 am	WIL B 122
Discussion:	Monday	11:10 am – 12:10 pm	WIL C 205 — **Group 1**
	Thursday	11:10 am – 12:10 pm	WIL C 205 — **Group 2**

Textbook: Blanchard, Devaney, Hall: *Differential Equations.* **4th edition**, Brooks/Cole – CENGAGE Learning, 2012, ISBN 0-495-56198-3 .

Further suggested readings:

1. P. Deuflhard, F. Bornemann: *Scientific Computing with Ordinary Differential Equations.* Texts in Applied Mathematics, Springer Verlag, New York, 2010, ISBN 1-441-93011-6 .
2. R. Redheffer: *Introduction to Differential Equations.* Jones and Bartlett, 1992, ISBN 0-86720-289-0.
3. W. Walter: *Ordinary Differential Equations.* Graduate Texts in Mathematics, Springer Verlag, New York, 1998, ISBN 0-387-98459-3.

Examination/Grading:

We will have one midterm exam during normal lecture time. It will very probably be held on Thursday, May 30th, 2013. The final exam is scheduled from 1:00 p.m. to 2:30 p.m. on Monday, July 15th, 2013. It is Boston University's policy that you must take the final at the scheduled time.

In addition to the midterm and the final, you will be required to submit written work during the semester. This work will include solutions to weekly homework sets and one project report. You will also be asked to present your solution of a homework problem on the blackboard at least once during the semester in your discussion session.

Normally, homework problems will be assigned during lecture on Monday and must be handed in before or at the beginning of your discussion session the following week.

Your final grade will be determined by applying the following weighting scheme to your grades:

Homework **30%**
Project report **10%**
Midterm exam **20%**
Final exam **40%**

Course schedule and contents based on the textbook

Week	Time	Lecture	Section	Discussion
1	08/04/13	What is an ODE, Examples	1.1	**both groups**
	11/04/13	Separation of Variables	1.2	**11/04/13**
2	15/04/13	Slope Fields, Nonanalytic Techniques	1.3 + 1.4	15/04/13
	18/04/13	Existence & Uniqueness of Solutions	1.5	18/04/13
3	22/04/13	Equilibria and Bifurcations	1.6 + 1.7	22/04/13
	25/04/13	Linear Problems, Undetermined Coefficients	1.8	25/04/13
4	29/04/13	Integrating Factors	1.9	29/04/13
	02/05/13	First-Order Systems	2.1 + 2.2	02/05/13
5	06/05/13	Damped Harmonic Oscillator, Decoupling	2.3 + 2.4	**06/05/13**
	09/05/13	**Holiday:** Please go to Discussion on **Monday!**		**both groups**
6	13/05/13	Explicit Numerical Methods	2.5 + 7.x	13/05/13
	16/05/13	Linear Systems	3.1 + 3.2	16/05/13
7	20/05/13	**Holiday:** Please go to Discussion on **Thursday!**		**both groups**
	23/05/13	Phaseplane for various Eigenvalues	3.3	**23/05/13**
8	27/05/13	Complex and Repeated Eigenvalues	3.4 + 3.5	27/05/13
	30/05/13	**MIDTERM EXAM**		30/05/13
9	03/06/13	Second-Order Linear Equations	3.6 + 3.7	03/06/13
	06/06/13	3D Linear Systems	3.8	06/06/13
10	10/06/13	Forced Harmonic Oscillator	4.1 + 4.2	10/06/13
	13/06/13	Resonance	4.3 + 4.4	13/06/13
11	17/06/13	Equilibrium Point Analysis	5.1 + 5.2	17/06/13
	20/06/13	Hamiltonian Systems	5.3	20/06/13
12	24/06/13	Dissipative Systems	5.4	24/06/13
	27/06/13	Periodic Forcing and Chaos	5.6	27/06/13
13	01/07/13	Introduction to Laplace Transforms	6.1	01/07/13
	04/07/13	Second-Order Equations	6.3	04/07/13
14	08/07/13	Discontinuity and Impulse Forcing	6.2 + 6.4	08/07/13
	11/07/13	*Review of Exam Material*		11/07/13
15	15/07/13	**FINAL EXAM**		15/07/13
	18/07/13	*... other finals ...*		18/07/13