Syllabus

APMA 0350: Applied Ordinary Differential Equations (Fall 2018)

Instructor: Björn Sandstede
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- Office Hours: Mondays 9-10am and Tuesdays 10:30-11:30am

Please talk with me after class or come to my office hours, whether you want to talk about the class or any other topic. If you want to stop by at my office outside of office hours, please do so: if my door is open, and nobody else is in my office, I am happy to talk. Aside from talking in person, email is the best way to contact me: I will typically respond to you on the same day if I receive your email before 8pm.

Learning goals and objectives:

This course provides a comprehensive introduction to ordinary differential equations and their applications. During the course, you will see how applied mathematicians use ordinary differential equations to solve practical applications, from understanding the underlying problem, creating a differential-equations model, solving the model using analytical, numerical, or qualitative methods, and interpreting the findings in terms of the original problem. We will also learn about the underlying rigorous theoretical foundations of differential equations.

By the end of the course, you will be able to
- create differential-equation models for a range of applications;
- determine whether an differential equation has a solution and if the solution is unique;
- analyse and solve differential equations using qualitative, analytical, and numerical techniques;
- interpret solutions to the mathematical models in the original applied context.

I am excited about this class. Differential equations serve as models for many processes and have led to significant insights into nature and technology. One important example is climate models. One of my other favorite examples of the impact of differential equations is a paper by Perelson et al. published in 1996 in Science that used a combination of experimental data and a linear differential equation of the type that we will solve in class to show that HIV viruses replicate so fast that single-drug therapies for HIV will very unlikely work (we will read this paper in the course).

Prerequisites:
- Intermediate Calculus: Math 0100, 0170, 0180, 0190, 0200, or 0350;
- Linear Algebra: Math 0520 or 0540 (can be taken concurrently).

Time expectations:

Class time	39 hours
Reviewing class (2hr/week)	26 hours
Homework (4hr/week)	52 hours
Problem-solving sessions	16 hours
Midterm preparation (10hr/midterm)	20 hours
Final exam preparation	30 hours
Total for semester	**183 hours**

Assessment:

Homework	35%
Midterm 1	15%
Midterm 2	15%
Final examination	35%

Provisional grading scale:

A	90-100%
B	80-89%
C	70-79%

This grading scale is subject to adjustment, especially in borderline cases; adjustments may take into account improvements over the semester. Minimum percentages for grade cut-offs will not be higher than in the scale above.

Textbook: No textbook is required: I will distribute detailed lecture notes for this course. Here are a few resources that provide additional perspectives on the material:

- David Logan: A first course in differential equations. Springer (available for free).
- James Meiss: Differential Dynamical Systems (Links to an external site) Links to an external site.
  . SIAM (available for free).
- Steven Strogatz. *Nonlinear Dynamics and Chaos.* Westview Press.

Homework assignments:
Assignments will be available on Canvas on Thursdays, and homework will be due on Thursdays at 10:20am. You can, and are strongly encouraged to, collaborate on homework assignments: however, assignments must be written up separately and individually.

Problem-solving sessions:
During the weekly problem-solving sessions, you will work in groups of three on guided projects to review, deepen, and expand your understanding of the course material, and apply the

techniques we learned about to models. Participation in these sessions is not required but highly recommended!

Accommodations for students with disabilities:
If you need accommodations for classes, assignments, or exams, please contact me as soon as possible. Please also contact the Student and Employee Accessibility Services (by phone 401-863-9588 or online at http://brown.edu/Student_Services/Office_of_Student_Life/seas/index.html).

Diversity and inclusion statement:
I would like to create a learning environment for you in which you can learn comfortably and productively and that supports a diversity of thoughts, perspectives, and experiences, and honors your identities (including race, gender, class, sexuality, religion, ability, …). Diversity of voices and of minds makes our ability to do science and answer questions about the world we all inhabit stronger. If you have a name and/or set of pronouns that differ from those that appear in your official Brown records, please let me know! Also, if you feel that your performance in the class is being impacted by your experiences outside of class, please do not hesitate to come and talk with me. I want to be a resource for you. If you prefer to speak with someone outside of the course, Dean Bhattacharyya (Associate Dean of the College for Diversity Programs) is a great resource. I am still in the process of learning about inclusion and diverse perspectives & identities. If something was said in class (by anyone) that made you feel uncomfortable, please talk to me about it.

The fine print …

- Canvas: All announcements and assignments will be posted exclusively on Canvas: please make sure you receive notifications from Canvas so that you stay informed of announcements and deadlines.
- Lectures: I strongly encourage you to come to all class meetings. Attending class allows you to see the material firsthand and to ask questions; we will also have small-group discussions during class that will enable you to spot any conceptual difficulties quickly.
- Homework: Late homework assignments can create unfair situations and also causes considerable inconvenience to the TAs. Hence, no credit will be given for late work unless you have a legitimate excuse (illness/emergency), together with verification.
- Midterm exams will not be given at times other than the scheduled slots, except when unavoidable or in cases of illness or emergencies: please contact me as soon as you can and provide documentation. If you are an athlete or have other competitions during midterms, please let me know as soon as you know so that we can plan accordingly. Thank you!
- Final exams: I am not allowed to reschedule final exams; if you have a conflict, please see a Dean in the Dean of the College's office for final exam excuses.

Course content:

- Introduction:
  - What are differential equations, what is a solution, sample models, classification
- First-order equations:
  - Qualitative approach
  - Separable equations
  - Existence and uniqueness theorem
  - Linear equations
  - Applications: population growth, bathtub models, mixing, …
  - Proof of existence and uniqueness theorem
- Numerical methods:
  Euler, Heyn, Runge-Kutta methods; introduction to Matlab
- *Midterm 1: Tuesday, 9 October 2018, in class*
- Linear systems:
  - Fundamental matrix solutions and matrix exponentials
  - Computing matrix exponentials: eigenvalues and eigenvectors
  - Inhomogeneous equations
  - Applications: forced linear pendulum, stage-structured populations
- *Midterm 2: Thursday, 15 November 2018, in class*
- Nonlinear systems:
  - Introduction: geometry, particle trajectories, definitions
  - Equilibria, stability, periodic orbits
  - Modelling: infectious diseases, pendulum, stage-structured populations, traffic flow
- *Final examination: Thursday, 20 December 2018, during 9am-12pm, location TBD*