BMA 771, Fall 2017 **Alun L. Lloyd**

The Course in a Sentence:

Motivated by the study of models of biological systems, we develop the qualitative theory of ordinary differential equations.

Administrative Details

Course website http://alun.math.ncsu.edu/bma771

Email: alun_lloyd@ncsu.edu

Textbook: Strogatz 'Nonlinear Dynamics and Chaos'

> More from a physical scientist's viewpoint
> Less discussion of modeling philosophy, model formulation and model criticism
> Not too mathematical (no proofs!)
>
> We follow Strogatz, and will cover chapters 1-8.

Grading: homework 50%, mid-term (Wednesday, October 11th—soon after Fall Break; date might change if I have travel) 20%, final 30%

Homework: typically one per week. Usually will be due on Thursday, either in class or to my mailbox (406 Cox Hall; if closed, leave under my office door: Cox 306) by 5pm.

Email: I will send out emails to the class. Make sure you are checking the correct account (check your email settings in MyPackPortal).

Office hours: 306 Cox Hall
Tuesday 10:30-11:30, Wednesday 10:30-11:30, or by appointment.

Please make use of office hours if you need help.

Prerequisites: Comfortable with calculus. Linear algebra useful (eigenvalues & eigenvectors of 2x2 and 3x3 matrices). Some exposure to differential equations would also be useful. Experience with matlab or equivalent also helpful.

We can work on gaps, e.g. during office hours. Let me know!

BMA/MA/ST 771: Biomathematics I. Differential Equations in Biology (3 CR)

1. Fall 2017. Monday/Wednesday, 3pm-4:15pm, SAS 1220

Instructor: Alun L. Lloyd
Office: Cox 306
Phone: 515-1910
Email: alun_lloyd@ncsu.edu

Office hours: Tuesday 10:30-11:30, Wednesday 10:30-11:30, or by appointment

2. Pre-requisites: Comfortable with calculus. Linear algebra useful (eigenvalues & eigenvectors of 2x2 and 3x3 matrices). Some exposure to differential equations would also be useful. Experience with matlab or equivalent also helpful.

3. Student Learning Outcomes

After completing this course, a student should be able to:

a. Give examples of well-known mathematical models of biological systems and describe how mathematical approaches have informed biological understanding
b. Formulate an ordinary differential equation model for a given biological system and critique the assumptions that underlie the model
c. Use mathematical approaches to analyze ordinary differential equation models, including finding analytic solutions, qualitative analyses and linear stability analyses
d. Numerically simulate a given ordinary differential equation model
e. Describe the types of dynamical behavior exhibited by low-dimensional differential equation models and the bifurcations involved in changes between these dynamics

4. Textbook: Strogatz 'Nonlinear Dynamics and Chaos', 2nd edn, 2014. Westview Press. Listed at $65 on amazon.com

No other course-related expenses

5. Course Overview (Differs from current description in Courseleaf)

Motivated by the study of models of biological systems, we develop the qualitative theory of ordinary differential equations. Differential equations on the line, circle, plane and in higher dimensions. Study of equilibrium points and their stability; bifurcations, including saddle-node and transcritical; stable, unstable and center manifolds of equilibrium points. Multiple equilibria and hysteresis. Hopf bifurcations, limit cycles and their stability. If time permits: chaotic dynamics and their characterization. Numerical simulation will be used throughout to illustrate and explore dynamics.

6. Course Structure: Two 75 minute lectures per week.

7. Course Schedule: see below

8. Statement on Transportation: not applicable

9. Statement on Safety and Risk Assumptions: not applicable for this lecture-based course

10. Grade Determination

Homework: 50% (homework will usually be weekly; not all problems will necessarily be graded, but I will state if this is the case)
Mid-term test: 20% (In class, on Wednesday, October 11th—soon after Fall Break; date might change if I have travel)

Final exam: 30% (Scheduled for 1-4pm, Monday December 11th in 1220 SAS. There may be a take-home component.)

Final grades will be calculated in the following format:

Letter	**Percent**
A+	96-100
A	92-95.9
A-	88-91.9
B+	84-87.9
B	79-83.9
B-	75-78.9
C+	71-74.9
C	68-70.9
C-	65-67.9
D+	63-64.9
D	60-62.9
D-	58-59.9
F	below 58%

The instructor reserves the right to amend these grade boundaries **downwards**; the given scores will be guaranteed to receive the stated grade.

11. Policy on Late Assignments

Unless you have a documented university-sanctioned excuse or have another extenuating circumstance at the instructor's discretion, the instructor reserves the right to deduct marks if homework is late, scoring late homeworks out of 80% rather than 100%, and take further action if homework is persistently late.

12. Policies on Attendance, Absences and Scheduling Makeup Work

Attendance is optional but highly recommended. If at all possible, please let me know if you will miss a class.

13. Statement for Students with Disabilities

"Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with the Disability Services Office at Suite 2221, Student Health Center, Campus Box 7509, 919-515-7653. For more information on NC State's policy on working with students with disabilities, please see the Academic Accommodations for Students with Disabilities Regulation (REG 02.20.01)."

14. N.C. State University Polices, Regulations, and Rules (PRR)

Students are responsible for reviewing the PRRs which pertain to their course rights and responsibilities. These include: http://policies.ncsu.edu/policy/pol-04-25-05 (Equal Opportunity and Non-Discrimination Policy Statement), http://oied.ncsu.edu/oied/policies.php (Office for Institutional Equity and Diversity), http://policies.ncsu.edu/policy/pol-11-35-01 (Code of Student Conduct), and http://policies.ncsu.edu/regulation/reg-02-50-03 (Grades and Grade Point Average)."

Course Outline (Chapters from Strogatz). More detail available online, including a detailed list of learning objectives for the material from Strogatz.

Chapter One: Introduction (one week)

Chapter Two: Flows on the line (two weeks)

Chapter Three: Bifurcations (two weeks)

Chapter Four: Flows on the circle (one week)

Chapter Five: 2D Linear systems (one week)

Chapter Six: 2D Nonlinear systems and the phase plane (two weeks)

Chapter Seven: Limit cycles (one week)

Chapter Eight: Bifurcations revisited (two weeks)

Miscellaneous topics (three weeks)
Flows on the torus (quasiperiodicity)
Variational equations: Floquet multipliers and stability of limit cycles
Analysis of limit cycles via Poincare sections and return maps
One dimensional maps (*** this topic is often covered in homework questions that overlap with class material on differential equations)
Chaotic dynamics in 1D maps and 3D ODEs: Lyapunov exponents and sensitive dependence on initial conditions
Sensitivity analysis and parameter estimation