CAAM/STAT 31410 Applied Dynamical Systems
Autumn 2020 Syllabus

Instructor – Mary Silber  (she/her/hers) – e-mail: msilber@uchicago.edu

Course Assistant

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Course Webpage – Canvas  : https://courses.uchicago.edu/ (Login with CNet ID)

- Check often! Handouts/notes/HWs/announcements are all posted there.

Course Description: This course is an introduction to dynamical systems in the setting of nonlinear ordinary differential equations. The focus is on basic existence-uniqueness theorems for ODEs, stability of equilibria and periodic solutions, existence and uniqueness of invariant manifolds, methods of bifurcation theory including center manifold reduction, normal form transformation and global bifurcations, as well as chaotic dynamics. As time permits we will explore canonical examples of forced nonlinear oscillators, fast-slow systems, and Hamiltonian systems, drawing from the mathematical modeling of physical and biological systems. While geometric perspectives will be emphasized, assignments will also introduce asymptotic methods for analysis, and use numerical simulation as an exploratory tool.

Course Prerequisites  This course assumes students have a background in ordinary differential equations and linear algebra at the undergraduate level, and an interest in mathematical modeling for applications. The course requires some minimal experience with, or willingness to learn, simple programming for solving ordinary differential equations, e.g. using built-in ODE solvers in Python, Matlab or Mathematica.


Tentative Course Schedule, stay tuned for revisions:

- Week 1: Introduction to course, review linear differential equations, including Floquet theory.
- Week 2: Review existence and uniqueness of solutions for differential equations; dynamical systems perspective introduced.
- Week 5: Invariant manifolds. Homoclinic bifurcation.

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• Week 6: Local bifurcations. Center Manifold Reduction. Normal Forms.
• Week 7: Fast-slow systems. Method of Averaging
• Week 8: Chaotic Dynamics. Lyapunov Exponents.
• Week 9: Homoclinic Tangles and Melnikov Theory.

Zoom Office Hours:

• Mary Silber: TBA, and by appointment (msilber@uchicago.edu)
• Kim Liu: TBA, and by appointment (kimberlyliu@uchicago.edu)

Grade Components

• Homework (60%): I will assign a “substantial problem” every week or two, and grade it based on how far you take it, on a 5 point scale (think check-minus-minus to check-plus-plus).
• Presentation (10%): A list of specialized or background topics will be provided, on an ongoing basis. You must pick one at some point in the quarter to present, either during class or via a recorded 10-15 minute presentation. This can be done individually, or, with my approval, by a small group. I will advise around this as needed.
• Final Exam (30%): A timed, open note, open book exam, to be arranged during final exam week.
• Extra Credit (10%): There is the possibility to earn up to 10% in extra credit by helping out your classmates and me, e.g. holding help sessions around background material, preparing a tutorial for numerical computations, having your solution to homework chosen for distribution to class as a model of clarity, ingenuity, creativity, completeness,...

Homework Policies

• I use the online submission of homework feature on Canvas:
  
  https://courses.uchicago.edu/ (log in with CNet ID and password)
  
  – You can type/LaTeX your homework and submit a pdf, or
  – scan your handwritten homework and then upload it to Canvas.

• For each assignment, please combine your work (text and graphs) in a single file for submission, not multiple ones.
• You can submit a single homework multiple times, before the due time. So if you want to correct a mistake in your submitted homework, you can just correct it and submit it again. We will grade the last version that is submitted prior to the submission deadline.
• Late homework will not necessarily get graded, or, even if accepted and graded, it may be marked down for being late.
• Homework Collaboration: You are encouraged to discuss course material and homework with other students, with the following restrictions:
  
  – You must do the final write-up independently in your own words, and do your own computer work (codes, plots).
– If you receive substantial help on a problem, you must acknowledge it. This includes any online resources you use. Being resourceful with resources will not count against you!

• Problem solutions must be coherent and legible. Graphs must be properly labeled.
• Please show your work with enough detail that someone else in the class could reproduce your solution by simply following along.