THE OHIO STATE UNIVERSITY

COLLEGE OF ARTS AND SCIENCES

SYLLABUS: STATISTICS 8810 - STATISTICAL INFERENCE FOR DYNAMICAL SYSTEMS

AUTUMN 2022 (TENTATIVE COURSE SYLLLABUS)

Course overview

Instructor

Instructor: Dr. O.A. Chkrebtii
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Office location: Cockins Hall (CH) 429
Phone number: 614-292-0292
Office hours: TBD

Course description

This course provides an introduction to some dynamical systems models that are commonly used in the natural sciences and engineer to describe natural phenomena. Particular emphasis will be given to ordinary differential equation (ODE) models and their numerical approximations. Inference for such models will be described as a nonlinear regression problem, and associated numerical techniques will be discussed. Both classical and Bayesian inferential approaches will be reviewed. This course also provides an introduction to semi-parametric modeling and inference, both in the classical and Bayesian settings. Likelihood-free inference for simulation-based dynamical systems will be introduced. State-space models will be discussed as the final topic. Students will gain experience in using R and STAN for statistical inference.

Course prerequisites

Although this course does not have any formal pre-requisites, sufficient background equivalent to the first year Ph.D. in Statistics or Biostatistics courses is needed to complete the course.

Course learning outcomes

By the end of this course, students should successfully be able to:

- Have sufficient understanding of ordinary differential equations to (i) understand the mechanism which is being described; (ii) suggest changes to the model based on a change in the mechanism; and (ii) be able to solve the system numerically under a variety of different regimes
- Familiarize themselves with the details of statistical inference, both classical and Bayesian, for dynamical systems in enough detail to (i) be able to read and critically analyze applied statistics papers where such models are being fit to data; and (ii) to be able to conduct such an analysis
- Become familiar with semi-parametric models and associated inference techniques, including understanding situations in which such models can be useful.
- Understand the need for and approaches to performing likelihood-free inference for simulation-based models

Course materials

There is no required textbook for the course. The primary resources will be notes and additional references assigned for reading by the instructor. The following are optional references, all of which are available online from the OSU library:

Optional

- D. M. Bates, D. G. Watts, Nonlinear Regression Analysis and Its Applications. Wiley, 1998.
- J. O. Ramsay and B. W. Silverman, Functional Data Analysis, Second Edition. Springer, 2005.
- J.C. Butcher, Numerical Methods for Ordinary Differential Equations. Wiley, 2008.

Course technology

For help with your password, university e-mail, Carmen, or any other technology issues, questions, or requests, contact the OSU IT Service Desk. Standard support hours are available at https://ocio.osu.edu/help/hours, and support for urgent issues is available 24x7.

- **Self-Service and Chat support:** http://ocio.osu.edu/selfservice
- **Phone:** 614-688-HELP (4357)
- **Email:** 8help@osu.edu
- **TDD:** 614-688-8743

Baseline technical skills necessary for online courses

- Basic computer and web-browsing skills

- Navigating Carmen

Technology skills necessary for this specific course

- Scanning and uploading a written document to Carmen

Necessary equipment

- Computer: current Mac (OS X) or PC (Windows 10+) with high-speed internet connection

Necessary software

- This class requires you to use the statistical software package called R (The R Project for Statistical Computing; http://www.r-project.org/). This software package is available as Free Software.
    - You can download R for Windows, Mac, and Linux, from the CRAN archive at https://cran.r-project.org.
    - An in-depth introduction to R is available at http://cran.r-project.org/doc/manuals/R-intro.pdf
    - Hands-on tutorials are available in the Swirl system, which you can learn about at http://swirlstats.com/. In particular, "R Programming: The basics of programming in R" is an appropriate first tutorial for students who have never used R.
- An easier to use interface to R is available in the software package RStudio. This package is available for Windows, Mac, and Linux and can be downloaded for free from http://rstudio.org. **Note that RStudio requires R to be installed.**

Course delivery

This class will take place in-person twice per week on Tuesdays and Thursdays, 12:40 pm - 2:30 pm in PEA0109. This half-semester course will run from Oct 17, 2022 to Dec 7, 2022.

Lectures will include a mix of slides and software demonstrations. Partial slides will be provided via Carmen to be filled in by students during the lectures.

All assignments will be posted on the Carmen course page. Office hours will be held in person. Zoom meetings available upon request as well.

Grading and faculty response

Grades

Assignment or category	Percentage
Homework (lowest grade will be dropped)	**40**
Midterm	**30**
Final Project	**30**
Total	**100**

See course schedule, below, for due dates

Assignment information

Assignments

- Will be assigned approximately every two weeks.

Participation

- You are required to attend the in-person lectures.

Final Project

- About midway through the course, a final group project will be assigned and will include an in-class presentation.

Late assignments

Late assignments will not be accepted, except when prior permission is given or when special circumstances arise. The lowest homework grade will be dropped for each student. Accommodations can be made in some special cases, so please notify me as soon as possible if any such situation arises.

Grading scale

93–100: A
90–92.9: A-
87–89.9: B+
83–86.9: B

80–82.9: B-
77–79.9: C+
73–76.9: C
70 –72.9: C-
67 –69.9: D+
60 –66.9: D
Below 60: E

Faculty feedback and response time

I am providing the following list to give you an idea of my intended availability throughout the course. (Remember that you can call **614-688-HELP** at any time if you have a technical problem.)

Grading and feedback

For large bi-weekly assignments, you can generally expect feedback within **7 days**.

E-mail

I will aim to reply to e-mails within **48 hours on school days**.

Attendance, participation, and discussions

Student participation requirements

Your participation is based on your in-person attendance and in-class discussion. The following is a summary of everyone's expected participation:

- **In-person class meetings**: **REQUIRED**
  Attendance of the in-person lectures is mandatory. Absences must be justified. However, formal attendance will not be taken during the class.
- **Logging in**: **AT LEAST ONCE PER WEEK**
  Be sure you are logging in to the course in Carmen each week, including weeks with holidays or weeks with minimal online course activity. (During most weeks you will probably log in many times.) If you have a situation that might cause you to miss an entire week of class, discuss it with me *as soon as possible.*
- **Office hours**: **OPTIONAL OR FLEXIBLE**
  Attending in-person office hours is optional.

Communication guidelines

The following are my expectations for how we should communicate as a class. Above all, please remember to be respectful and thoughtful.

- **Tone and civility**: Let's maintain a supportive learning community where everyone feels safe and where people can disagree amicably. Remember that sarcasm doesn't always come across online.
- **Citing your sources**: When we have academic discussions, please cite your sources to back up what you say. (For the textbook or other course materials, list at least the title and page numbers. For online sources, include a link.)

Other course policies

Health and safety

The Ohio State University Wexner Medical Center's Cornavirus Outbreak site (https://wexnermedical.osu.edu/features/coronavirus) includes the latest information about COVID-19 as well as guidance for students, faculty and staff.

Potential disruptions to instruction

- As much as is possible, students will have access to material online if they are unable to attend class because of positive diagnosis, symptoms, or quarantine required following contact tracing
- If the instructor is unable to be present in person because of positive diagnosis, symptoms, or quarantine following contact tracing, the course will temporarily shift to online instruction. Details will be given on the course website if this arises.

Student academic services

Student academic services offered on the OSU main campus http://advising.osu.edu/welcome.shtml.

Student support services

Student support services offered on the OSU main campus http://ssc.osu.edu.

Academic integrity policy

Policies for this online course

- **Homework and project assignments**: You are expected to produce original and independent work for homework and project assignments. Although students are encouraged to work together on homework assignments, all students must submit their

own written work **in their own words** (this includes any code). *Note that allowing others to copy your work is also considered academic misconduct*. Academic misconduct will not be tolerated and will be dealt with procedurally in accordance with University Rule 3335-31-02. (This policy can be found at http://oaa.osu.edu/coam.html.)

- **Reusing past work**: In general, you are prohibited in university courses from turning in work from a past class to your current class, even if you modify it. If you want to build on past research or revisit a topic you've explored in previous courses, please discuss the situation with me.
- **Falsifying research or results**: All research you will conduct in this course is intended to be a learning experience; you should never feel tempted to make your results or your library research look more successful than it was.
- **Collaboration and informal peer-review**: The course includes many opportunities for formal collaboration with your classmates. While study groups and peer-review of major written projects is encouraged, remember that comparing answers on an assignment is not permitted. If you're unsure about a particular situation, please feel free just to ask ahead of time.

Ohio State's academic integrity policy

It is the responsibility of the Committee on Academic Misconduct to investigate or establish procedures for the investigation of all reported cases of student academic misconduct. The term "academic misconduct" includes all forms of student academic misconduct wherever committed; illustrated by, but not limited to, cases of plagiarism and dishonest practices in connection with examinations. Instructors shall report all instances of alleged academic misconduct to the committee (Faculty Rule 3335-5-487). For additional information, see the Code of Student Conduct http://studentlife.osu.edu/csc/.

Copyright disclaimer

The materials used in connection with this course may be subject to copyright protection and are only for the use of students officially enrolled in the course for the educational purposes associated with the course. Copyright law must be considered before copying, retaining, or disseminating materials outside of the course.

Statement on title IX

Title IX makes it clear that violence and harassment based on sex and gender are Civil Rights offenses subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories (e.g., race). If you or someone you know has been sexually harassed or assaulted, you may find the appropriate resources at http://titleix.osu.edu or by contacting the Ohio State Title IX Coordinator, Kellie Brennan, at titleix@osu.edu

Accessibility accommodations for students with disabilities

The university strives to make all learning experiences as accessible as possible. In light of the current pandemic, students seeking to request COVID-related accommodations may do so through the university's request process, managed by Student Life Disability Services. If you anticipate or experience academic barriers based on your disability (including mental health, chronic, or temporary medical conditions), please let me know immediately so that we can privately discuss options. To establish reasonable accommodations, I may request that you register with Student Life Disability Services. After registration, make arrangements with me as soon as possible to discuss your accommodations so that they may be implemented in a timely fashion. SLDS contact information: slds@osu.edu; 614-292-3307; http://slds.osu.edu; 098 Baker Hall, 113 W. 12th Avenue.

Accessibility of course technology

This online course requires use of Carmen (Ohio State's learning management system) and other online communication and multimedia tools. If you need additional services to use these technologies, please request accommodations with your instructor.

- Carmen (Canvas) accessibility
- Streaming audio and video
- Synchronous course tools

Your mental health

As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce a student's ability to participate in daily activities. The Ohio State University offers services to assist you with addressing these and other concerns you may be experiencing. If you or someone you know are suffering from any of the aforementioned conditions, you can learn more about the broad range of confidential mental health services available on campus via the Office of Student Life's Counseling and Consultation Service (CCS) by visiting ccs.osu.edu or calling 614- 292-5766. CCS is located on the 4th Floor of the Younkin Success Center and 10th Floor of Lincoln Tower. You can reach an on call counselor when CCS is closed at 614-292-5766 and 24 hour emergency help is also available through the 24/7 National Suicide Prevention Hotline at 1-800-273- TALK or at suicidepreventionlifeline.org

Disclaimer

This syllabus should be taken as a fairly reliable guide for the course content. However, you cannot claim any rights from it and in particular we reserve the right to change due dates or the methods of grading and/or assessment if necessary. Any changes will be communicated to you through official course announcements.

Course schedule (tentative)

Week	Lecture	Topics, Readings, Assignments, Deadlines
1	1	Introduction to dynamical systems models used in the natural sciences and engineering
1	2	Introduction to dynamical systems models used in the natural sciences and engineering
2	1	Numerical methods for solving ODEs
2	2	Inference on model parameters via nonlinear regression – classical and Bayesian approach
3	1	Inference on model parameters via nonlinear regression – classical and Bayesian approach
2	2	Inference on model parameters via nonlinear regression – classical and Bayesian approach
4	1	Generalized smoothing and related semi-parametric estimation approaches
4	2	Generalized smoothing and related semi-parametric estimation approaches
5	1	Likelihood-free inference for simulation-based models
5	2	Likelihood-free inference for simulation-based models
6	1	State-space models and data assimilation
6	2	State-space models and data assimilation
7	1	Project Presentations
7	2	Project Presentations