SYLLABUS: STAT 4194
STATISTICAL ANALYSIS OF NETWORKS
SPRING 2026

Course overview

Instructor

Instructor: Subhadeep Paul
Email address: paul.963@osu.edu
Lectures: Tuesdays and Thursdays, 12:45pm–2:05pm in Cockins Hall 312
Office hours: Cockins Hall 231, Tuesdays 4:30 – 5:30 PM.

Teaching Assistant

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Prerequisite:

Prerequisites: Stat 3301 or equivalent.

Course description

The course is intended to introduce the field of statistical analysis of network data at the undergraduate level. The course will have a good mix of statistical methods and applications. We will discuss a variety of methods for analyzing network data and learn to apply those methods to datasets using R packages. Applications of these methods to network data from social sciences, economics, psychology, neuroscience, and biology will be discussed.

Module 1: Introduction

- Basic concepts and properties of graphs, motivation for network analysis,
- Historical context of network analysis (in statistics, sociology, math, physics, computer science etc.)
- Application areas of network data
- Community Detection
- Small-world property and heterogeneous degree distribution
- Data structures - single network, multi-layer network, time varying network, multimodal network

Module 2: Stochastic Block Models

- Erdos-Renyi random graphs and their properties.
- Stochastic Block Models – definition and properties, estimation methods - maximum likelihood, modularity optimization, variational methods, spectral methods
- Characterizing the error of community detection and evaluation of the methods
- Extensions - degree corrected, mixed membership, superimposed models, and graphons.

Module 3: Latent Space Models

- Modeling choices – social relations model, additive and multiplicative effects model
- Estimation and Inference
- Extensions - hyperbolic space, more complex data structures

Module 4: Dynamic and Multilayer networks

- Multilayer networks: models and methods
- Discrete time dynamic networks
- Continuous time interaction networks

Module 5: Additional topics (time permitting)

- Graph Neural Networks (GNN)
- Experiments under network interference

Course learning outcomes

Upon successful completion of the course, students will be able to

1. Compute various summary statistics and properties of network data
2. Fit statistical models to network data and assess model fit
3. Quantify accuracy of various methods of network analysis
4. Perform statistical learning tasks on network data including community detection, link prediction, and classification
5. Identify appropriate analysis strategies for more complex networked data structures including dynamic and multilayer networks
6. Apply the network analysis methods to network data obtained from a variety of disciplines.

Course materials and technologies

Textbooks

Required

Statistical Analysis of Network Data with R (2020) by Eric D. Kolaczyk and Gábor Csárdi, Springer New York, NY

The electronic version of this book is freely available to OSU students from the OSU library at this link (please log in with your OSU credentials)

https://library.ohio-state.edu/record=b9007501

(click on “connect to resource SpringerLink” to download a PDF copy).

Course material will be supplemented with typed lecture notes that will be provided regularly.

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
- An easier to use interface to R is available in the software package RStudio (now posit). This package is available for Windows, Mac, and Linux and can be downloaded for free from https://posit.co/. **Note that RStudio requires R to be installed.**

Grading and faculty response

Grades

Assignment or category	Percentage
Homework Assignments	**45**
Mid-term in-class Exam	**25**
Final Project and presentation	**30**
Total	**100**

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

Assignment information

Homework: Homework will be assigned regularly (about 5-6 assignments over the semester). It will consist of both written mathematical and numerical problems as well as data analysis problems that require you to write R codes. You are encouraged to work together on the problems, but each student must hand in their own work, written in their own words. Do not copy any part of another student's homework including computer output. Use of homework solutions distributed in previous offerings of the course or available on the web constitutes academic misconduct and will be handled according to university rules. All homework must be submitted online as a PDF file through the class website (carmen). For written problems you may take a picture of or scan your written solutions and upload them as a PDF file. For R based problems please submit typed solutions. Please be sure that the questions are clearly labeled, all supporting work (including computer code) can be easily identified, and that all figures/tables are referenced and interpreted in the text.

Please note late submission of assignments will be penalized at a rate of 10% of points received in the assignment per day they are late. The late penalty may be waived if prior exception has been sought**.** if you are unable to complete an assignment on time and need extra time, please get in touch with me as soon as possible so we can discuss your situation.

In-class midterm Exam: There will be one in-class midterm exam. This course has no final exam. Coverage of the midterm exam includes lecture material, assigned reading, and homework. The exam will be in-person at the usual lecture room during regular class hours. This will be a closed book/closed notes exam. Further details will be given in advance of the exam. Statistical tables will be provided as needed. Calculators may be used, but no communication devices are allowed (e.g. mobile phones). You may use one 8.5x11 inch handwritten sheet of paper (both sides) with formulas. Makeup exam requires a valid excuse and official proof if I am notified in advance or as soon as possible.

Final Project: There is one group project in this course. Students will be expected to work in groups of 3-4 people to complete the project. Each group will analyze a network dataset of their choice and present the findings during the final project presentation on the last day of classes.

You are permitted to use AI for assistance with writing code and solving the homework problems. You may also use AI for the final project. However, I require that you write the final solutions in the homework and the project in your own words.

Tentative Dates for exams and presentations:

In-class midterm exam: Tuesday, March 10, 2026, during class time.
Final project presentation: Thursday, April 23, 2026, during class time.

Faculty feedback and response time

I am providing the following list to give you an idea of my intended availability throughout the course.

Grading and feedback

For bi-weekly assignments, you can generally expect graded homeworks back within **14 days**.

E-mail

I will reply to e-mails related to course logistics and technical questions that can be answered over email within **24 hours on school days**. However, if you have questions on understanding the course materials or regarding the homework assignments, please consider visiting my office hours or the TA's office hours.

Other course policies

Academic integrity policy

Academic integrity is essential to maintaining an environment that fosters excellence in teaching, research, and other educational and scholarly activities. Thus, The Ohio State University and the Committee on Academic Misconduct (COAM) expect that all students have read and understand the University's Code of Student Conduct, and that all students will complete all academic and scholarly assignments with fairness and honesty. Students must recognize that failure to follow the rules and guidelines established in the University's Code of Student Conduct and this syllabus may constitute Academic Misconduct.

The Ohio State University's Code of Student Conduct (Section 3335-23-04) defines academic misconduct as: Any activity that tends to compromise the academic integrity of the University or subvert the educational process. Examples of academic misconduct include (but are not limited to) plagiarism, collusion (unauthorized collaboration), copying the work of another student, and possession of unauthorized materials during an examination. Ignorance of the University's Code of Student Conduct is never considered an excuse for academic misconduct, so please review the Code of Student Conduct and, specifically, the sections dealing with academic misconduct.

If an instructor suspects that a student has committed academic misconduct in this course, the instructor is obligated by University Rules to report those suspicions to the Committee on Academic Misconduct. If COAM determines that a student violated the University's Code of Student Conduct (i.e., committed academic misconduct), the sanctions for the misconduct could include a failing grade in the course and suspension or dismissal from the University.

If students have questions about the above policy or what constitutes academic misconduct in this course, they should contact the instructor.

Artificial Intelligence and Academic Integrity

There has been a significant increase in the popularity and availability of a variety of generative artificial intelligence (AI) tools, including ChatGPT, Sudowrite, and others. These tools will help shape the future of work, research and technology, but when used in the wrong way, they can stand in conflict with academic integrity at Ohio State. All students have important obligations under the Code of Student Conduct to complete all academic and scholarly activities with fairness and honesty. Our professional students also have the responsibility to uphold the professional and ethical standards found in their respective academic honor codes. Specifically, students are not to use unauthorized assistance in the laboratory, on field work, in scholarship, or on a course assignment unless such assistance has been authorized specifically by the course instructor. In addition, students are not to submit their work without acknowledging any word-for-word use and/or paraphrasing of writing, ideas or other work that is not your own. These requirements apply to all students undergraduate, graduate, and professional.

To maintain a culture of integrity and respect, these generative AI tools should not be used in the completion of course assignments unless an instructor for a given course specifically authorizes their use. Some instructors may approve of using generative AI tools in the academic setting for specific goals. However, these tools should be used only with the explicit and clear permission of each individual instructor, and then only in the ways allowed by the instructor.

Copyright for instructional materials

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.

Creating an Environment Free from Harassment, Discrimination, and Sexual Misconduct

The Ohio State University is committed to building and maintaining a welcoming community. All Buckeyes have the right to be free from harassment, discrimination, and sexual misconduct. Ohio State does not discriminate on the basis of age, ancestry, color, disability, ethnicity, gender, gender identity or expression, genetic information, HIV/AIDS status, military status, national origin, pregnancy (childbirth, false pregnancy, termination of pregnancy, or recovery therefrom), race, religion, sex, sexual orientation, or protected veteran status, or any other bases under the law, in its activities, academic programs, admission, and employment. Members of the university community also have the right to be free from all forms of sexual misconduct: sexual harassment, sexual assault, relationship violence, stalking, and sexual exploitation.

To report harassment, discrimination, sexual misconduct, or retaliation and/or seek confidential and non-confidential resources and supportive measures, contact the Civil Rights Compliance Office (CRCO):

Online reporting form: http://civilrights.osu.edu/
Call 614-247-5838 or TTY 614-688-8605
civilrights@osu.edu

The university is committed to stopping sexual misconduct, preventing its recurrence, eliminating any hostile environment, and remedying its discriminatory effects. All university employees have reporting responsibilities to the Civil Rights Compliance Office to ensure the university can take appropriate action:

- All university employees, except those exempted by legal privilege of confidentiality or expressly identified as a confidential reporter, have an obligation to report incidents of sexual assault immediately.
- The following employees have an obligation to report all other forms of sexual misconduct as soon as practicable but at most within five workdays of becoming aware of such information: 1. Any human resource professional (HRP); 2. Anyone who supervises faculty, staff, students, or volunteers; 3. Chair/director; and 4. Faculty member.

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 24/7 **by dialing 988 to reach the Suicide and Crisis Lifeline**.

Religious accommodation

Ohio State has had a longstanding practice of making reasonable academic accommodations for students' religious beliefs and practices in accordance with applicable law. In 2023, Ohio State updated its practice to align with new state legislation. Under this new provision, students must be in early communication with their instructors regarding any known accommodation requests for religious beliefs and practices, providing notice of specific dates for which they request alternative accommodations within 14 days after the first instructional day of the course. Instructors in turn shall not question the sincerity of a student's religious or spiritual belief system in reviewing such requests and shall keep requests for accommodations confidential.

With sufficient notice, instructors will provide students with reasonable alternative accommodations with regard to examinations and other academic requirements with respect to students' sincerely held religious beliefs and practices by allowing up to three absences each semester for the student to attend or participate in religious activities. Examples of religious accommodations can include, but are not limited to, rescheduling an exam, altering the time of a student's presentation, allowing make-up assignments to substitute for missed class work, or flexibility in due dates or research responsibilities. If concerns arise about a requested accommodation, instructors are to consult their tenure initiating unit head for assistance.

A student's request for time off shall be provided if the student's sincerely held religious belief or practice severely affects the student's ability to take an exam or meet an academic requirement and the student has notified their instructor, in writing during the first 14 days after the course begins, of the date of each absence. Although students are required to provide notice within the first 14 days after a course begins, instructors are strongly encouraged to work with the student to provide a reasonable accommodation if a request is made outside the notice period. A student may not be penalized for an absence approved under this policy.

If students have questions or disputes related to academic accommodations, they should contact their course instructor, and then their department or college office. For questions or to report discrimination or harassment based on religion, individuals should contact the Civil Rights Compliance Office. (Policy: Religious Holidays, Holy Days and Observances)

Intellectual diversity

Ohio State is committed to fostering a culture of open inquiry and intellectual diversity within the classroom. This course will cover a range of information and may include discussions or debates about controversial issues, beliefs, or policies. Any such

discussions and debates are intended to support understanding of the approved curriculum and relevant course objectives rather than promote any specific point of view. Students will be assessed on principles applicable to the field of study and the content covered in the course. Preparing students for citizenship includes helping them develop critical thinking skills that will allow them to reach their own conclusions regarding complex or controversial matters.

Grievances and Solving Problems

According to University Policies, if you have a problem with this class, you should seek to resolve the grievance concerning a grade or academic practice by speaking first with the instructor or professor. Then, if necessary, take your case to the department chairperson, college dean or associate dean, and to the provost, in that order. Specific procedures are outlined in Faculty Rule 3335-8-23. Grievances against graduate, research, and teaching assistants should be submitted first to the supervising instructor, then to the chairperson of the assistant's department.

Accessibility accommodations for students with disabilities

Requesting accommodations

The university strives to maintain a healthy and accessible environment to support student learning in and out of the classroom. 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.

If you are ill and need to miss class, including if you are staying home and away from others while experiencing symptoms of a viral infection or fever, please let me know immediately. In cases where illness interacts with an underlying medical condition, please consult with Student Life Disability Services to request reasonable accommodations. You can connect with them at slds@osu.edu; 614-292-3307; or slds.osu.edu.

Accessibility of course technology

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

- Canvas accessibility (go.osu.edu/canvas-accessibility)
- Streaming audio and video
- CarmenZoom accessibility (go.osu.edu/zoom-accessibility)

- Collaborative course tools

Course schedule (tentative)

Refer to the Carmen course for up-to-date assignment due dates.

Week	Dates	Topics
1	01/13, 01/15	Descriptive summaries and properties of graphs, visualization of network data
2	01/20, 01/22	Centrality measures, clustering coefficient, small-world property
3	01/27, 01/29	Community structure and modularity
4	02/03, 02/05	Properties of Erdos-Renyi random graphs and simulation
5	02/10, 02/12	The stochastic block model (SBM), maximum likelihood estimation
6	02/17, 02/19	SBM variational EM method, fitting SBM to networks
7	02/24, 02/26	Spectral methods for community detection and SBM
8	03/03, 03/05	Accessing accuracy of community detection – overview of theory and simulation-based evidence
9	03/10, 03/12	In-class midterm exam, Extensions of SBM- degree corrected and mixed membership
10	03/17, 03/19	Spring break – no classes
11	03/24, 03/26	Latent space models (LSM) – motivation and description
12	03/31, 04/02	Estimation and inference in LSMs, fitting LSMs to network data
13	04/07, 04/09	LSM – additive and multiplicative effects, assessing model fit
14	04/14, 04/16	Multilayer networks – examples, descriptive properties, models and methods
15	04/21, 04/23	dynamic network models and methods, Project presentation