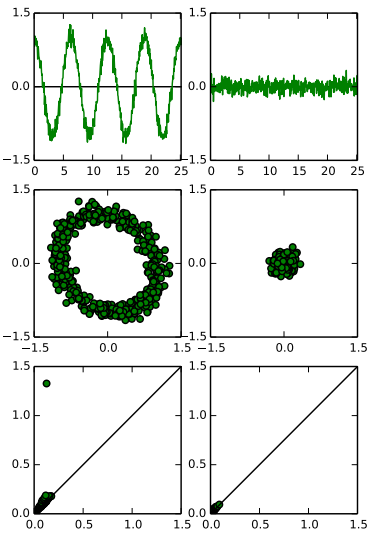
CMSE 890: Topological Data Analysis
Class: T/Th 12:40 - 2:00, 1225 Engineering Building
Credit hours: 3

Instructor: Elizabeth Munch, Ph.D.
Assoc Prof, Dept of CMSE and Dept of Math
Office: 428 South Shaw Lane
Engineering Bldg, Rm 1511
E-mail: muncheli@msu.edu
Phone: 517-432-0619

Slack: cmse-courses.slack.com (Click for invite link).
Join the `#cmse890-tda-f25` channel.
Office Hours: Tuesdays and Thursdays by appointment. Zoom or EGR 1511.
Find a time at elizabethmunch.com/officehours

Course Description:

Topology is the study of shapes. Recently, a great deal of work has gone into the study of using topological methods for problems in science and engineering, particularly in data analysis. This new research topic goes by many names, most often Computational Topology, Applied Topology, or Topological Data Analysis (TDA). We will work with many disparate fields such as algebraic topology, geometry, linear algebra, abstract algebra, algorithms, statistics, and sheaf theory in order to understand recent results in the field. We will study and use efficient software for the computation of things discussed in class, such as persistent homology and Reeb graphs. We will also look at applications in fields such as computer graphics, image analysis, sensor networks, clustering, time series analysis, and genetics.



Prerequisites:

Mathematical prerequisites: Linear algebra. Some familiarity of computer programming with packages such as Python, R, or MATLAB is expected. Individuals with backgrounds in mathematics, engineering, computer science, or other natural sciences with some computational training, will find this class of interest.

Website:

The website, https://lizliz.github.io/CMSE890-TDA-Fall2025/, has information about the course and any necessary files. The majority of announcements will come through the Slack channel so be sure to keep up to date with that.

Textbook:

1. *Required:* Tamal K. Dey and Yusu Wang. Computational Topology for Data Analysis, 2021. Free PDF available at https://www.cs.purdue.edu/homes/tamaldey/book/CTDAbook/CTDAbook.html
2. *Recommended:* Herbert Edelsbrunner & John Harer. Computational Topology: An Introduction. American Mathematical Society, 2010.
3. *Recommended:* Munkres, James R. Elements of algebraic topology. Vol. 2. Reading: Addison-Wesley, 1984.

Grading: Your grade will be based on the following components:

- **Reading:** This course will be extremely reading heavy. Since we are looking at state of the art research, this will be a mix of textbook reading and research papers. Other than the textbook, all readings will be posted on the website.
- **Homework:** I will assign a problem or two after every class. At the beginning of the next class, I will have someone present their solution to the problem(s). You should expect to present approximately twice during the semester, but I reserve the right to modify this as needed.
- **Participation:** This content is very interactive and I expect you to participate in class discussions. While I will not be directly grading participation, this content has an exponential learning curve and I expect you to keep up with the material. Missing classes, particularly in the beginning, will make the later content sound like gibberish.

Required materials:

- I will have some days that include running code in class. I recommend having a laptop that can run Python. I will try to warn you for days that will require a laptop.
- I will provide skeleton slides that I will annotate in class as well. These should be available on the course website prior to the class. If you want a physical copy, it is your responsibility to print them out before class.

Tentative Schedule:
We will be approximately following the Dey/Wang textbook. A schedule of topics can be found on the course website at https://lizliz.github.io/CMSE890-TDA-Fall2025/. Note that this schedule is only provided as a guide and is very likely subject to change during the semester.

Inclusive classroom behavior:
Respectful and responsible behavior is expected at all times, which includes not interrupting other students, refraining from non-course-related use of electronic devices or additional software during class sessions, and not using offensive or demeaning language in our discussions. Flagrant or repeated violations of this expectation may result in ejection from the classroom, grade-related penalties, and/or involvement of the university Ombudsperson. In particular, behaviors that could be considered discriminatory or harassing, or unwanted sexual attention, will not be tolerated and will be immediately reported to the appropriate MSU office (which may include the MSU Police Department).
In addition, MSU welcomes a full spectrum of experiences, viewpoints, and intellectual approaches because they enrich the conversation, even as they challenge us to think differently and grow. However, we believe that expressions and actions that demean individuals or groups comprise the environment for intellectual growth and undermine the social fabric on which the community is based. These demeaning behaviors are not welcome in this classroom.

Accommodations for Students with Disabilities:
(from the Resource Center for Persons with Disabilities (RCPD): Michigan State University is committed to providing equal opportunity for participation in all programs, services and activities. Requests for accommodations by persons with disabilities may be made by contacting the Resource Center for Persons with Disabilities at 517-884-RCPD or on the web at http://rcpd.msu.edu. Once your eligibility for an accommodation has been determined, you will be issued a Verified Individual Services Accommodation ("VISA") form. Please present this form to the instructor at the start of the term and/or two weeks prior to the accommodation date (test, project, etc.). Requests received after this date may not be honored.

Academic honesty:
Intellectual integrity is the foundation of the scientific enterprise. In all instances, you must do your own work and give proper credit to all sources that you use in your papers and oral presentations – any instance of submitting another person's work, ideas, or wording as your own counts as plagiarism. This includes failing to cite any direct quotations in your essays, research paper, class debate, or written presentation. The MSU College of Engineering adheres to the policies of academic honesty as specified in the General Student Regulations 1.0, Protection of Scholarship and Grades, and in the all-University statement on Integrity of Scholarship and Grades, which are included in Spartan Life: Student Handbook and Resource Guide. Students who plagiarize will receive a 0.0 in the course. In addition, University policy requires that any cheating offense, regardless of the magnitude of the infraction or punishment decided upon by the professor, be reported immediately to the dean of the student's college. (See also the Academic Integrity webpage.)
It is important to note that plagiarism in the context of this course includes, but is not limited to, directly copying another student's solutions to assignments; copying materials from online sources, textbooks, or other reference materials without citing those references in your source code or documentation, or having somebody else do your in-class work or homework on your behalf. Any work that is done in collaboration with other students should state this explicitly, and have their names as well as yours listed clearly.
More broadly, we ask that students adhere to the Spartan Code of Honor academic pledge, as written by the Associated Students of Michigan State University (ASMSU):
"As a Spartan, I will strive to uphold values of the highest ethical standard. I will practice honesty in my work, foster honesty in my peers, and take pride in knowing that honor is worth more than grades. I will carry these values beyond my time as a student at Michigan State University, continuing the endeavor to build personal integrity in all that I do."

Limits to confidentiality:
Essays, journals, and other materials submitted for this class are generally considered confidential pursuant to the University's student record policies. However, students should be aware that University employees, including instructors, may not be able to maintain confidentiality when it conflicts with their responsibility to report certain issues to protect the health and safety of MSU community members and others. As the instructor, I must report the following information to other University offices (including the Department of Police and Public Safety) if you share it with me:

- suspected child abuse/neglect, even if this maltreatment happened when you were a child,
- allegations of sexual assault or sexual harassment when they involve MSU students, faculty, or staff,

and

- credible threats of harm to oneself or to others.

These reports may trigger contact from a campus official who will want to talk with you about the incident that you have shared. In almost all cases, it will be your decision whether you wish to speak with that individual. If you would like to talk about these events in a more confidential setting you are encouraged to make an appointment with the MSU Counseling Center.

Changes to Syllabus:
The syllabus may also be adjusted if needed. These types of changes will be announced during class, by email and/or in the course's slack channel.

Disruptive Behavior:
Article 2.III.B.4 of the Student Rights and Responsibilities (SRR) for students at Michigan State University states: "The student's behavior in the classroom shall be conducive to the teaching and learning process for all concerned." Article 2.III.B.10 of the SRR states that "The student and the faculty share the responsibility for maintaining professional relationships based on mutual trust and civility." General Student Regulation 5.02 states: "No student shall . . . interfere with the functions and services of the University (for example, but not limited to, classes . . .) such that the function or service is obstructed or disrupted. Students whose conduct adversely affects the learning environment in this classroom may be subject to disciplinary action through the Student Judicial Affairs office.

Grief Absence Policy:
Michigan State University is committed to ensuring that the bereavement process of a student who loses a family member during a semester does not put the student at an academic disadvantage in their classes. If you require a grief absence, you should complete the "Grief Absence Request" web form no later than one week after knowledge of the circumstance. I will work with you to make appropriate accommodations so that you are not penalized due to a verified grief absence.