MTH 593 – Special Topics in Mathematics – Topology

Cleveland State University, Department of Mathematics
Course Syllabus, Spring 2015

Class meetings: 4:00–5:50pm Tue in RT 1516, Thu in RT 403
Tue Feb 17 and Tue Feb 24 will also be in RT 403

Instructor: Peter Bubenik, Ph.D.

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Course description. The use of topology in analyzing data is an exciting twenty-first century development in topology, a subject that saw tremendous development throughout the twentieth century, and has had a big impact on many areas of mathematics. This course will provide an introduction to topology with an emphasis on using topology to analyze data. The course will be divided roughly evenly between time spent learning the material with white board, pencil and paper and time spent at the computer using software to perform topological data analysis.

Learning outcomes. To understand basic concepts in topology and be able to apply them to calculations. To be able to perform topological data analysis. To be able to communicate mathematics in writing. To learn a mathematical topic and/or analyze data independently and to effectively present this work in writing and orally.

Recommended resources.

- Gunnar Carlsson. Topological Pattern Recognition for Point Cloud Data.
- Herbert Edelsbrunner. A Short Course in Computational Geometry and Topology.
- Afra Zomorodian. Topology for Computing.
- Robert Ghrist. Elementary Applied Topology.
- Allen Hatcher. Algebraic Topology.

Software. We will be using Matlab and JavaPlex. It is not assumed that you have any experience with these.

Course work and assessment. The grading for the course will be based on four homework assignments, each worth 15%, and one project, worth 40%.

A: 100% – 93%, A-: 92% – 90%, B+: 89% – 86%, B: 85% – 83%, B-: 82% – 80%, C: 79% – 60%, F: 59% – 0%

Homework. You are encouraged to discuss the exercises with your classmates, but you must write up your own solutions. Copying solutions or allowing your solutions to be copied is considered cheating. If you are unable to do any of the homework ask me for help as soon as possible.

Project. You will work with one partner on a project suggested by me or on a project of your choosing that I have approved. You will submit a document on the results of your project, and you will also present your results to the class.

Attendance and Participation. It is expected that you attend class regularly and participate by asking and answering questions.

Tips for success:

- Before each lecture, read your notes from the previous lecture and read ahead using the recommended resources.
- We can spend time at the start of class looking at the assigned problems. Come to class with your questions ready.
- Ask questions during class; if something is confusing, you aren't the only who would like it to be clarified.
- Discuss the homework with your classmates.
- For help not specific to this course `myCSU` lists resources available to you. An academic resource that may be useful is the Tutoring & Academic Support Center. A health resource that may be useful is the Counseling Center. Financial Aid & Scholarships and Jobs & Careers may also be helpful.

Disabilities statement. Educational access is the provision of classroom accommodations, auxiliary aids and services to ensure equal educational opportunities for all students regardless of their disability. Any student who feels he or she may need an accommodation based on the impact of a disability should contact the Office of Disability Services at (216) 687-2015. The Office is located in MC 147. Accommodations need to be requested in advance and will not be granted retroactively.

Differences between MTH 493 and MTH 593. Graduate students will be required to do more work and will be held a higher qualitative standard. They should synthesize and apply knowledge at a more sophisticated level. They should demonstrate in writing and orally a more sophisticated understanding of the course material.

Course schedule.

Date	Room	Topic
Jan 13	RT 1516	Introduction to topology, simplicial complexes
Jan 15	RT 403	Introduction to Matlab
Jan 20	RT 1516	Simplicial chains, equivalence classes, simplicial homology
Jan 22	RT 403	Boundary matrices, homology
Jan 27	RT 1516	Filtrations, persistent homology
Jan 29	RT 403	JavaPlex, simplicial homology
Feb 3	RT 1516	The persistence algorithm
Feb 5	RT 403	Persistent homology
Feb 10	RT 1516	Geometric complexes, Nerve theorem, metric spaces
Feb 12	RT 403	Point cloud data
Feb 17	RT 403	Metric spaces
Feb 19	RT 403	Vietoris-Rips complex
Feb 24	RT 403	Witness complex
Feb 26	RT 403	Witness complex
Mar 3	RT 1516	Classification of persistence vector spaces
Mar 5	RT 403	Project
Mar 10	RT 1516	Barcodes, persistence diagrams, metrics, stability
Mar 12	RT 403	Project
Mar 17	RT 1516	Persistence landscapes, statistics, machine learning
Mar 19	RT 403	Project
Mar 24	RT 1516	Applications
Mar 26	RT 403	Project
Apr 7	RT 1516	Homotopy, fundamental group
Apr 9	RT 403	Presentations, project
Apr 14	RT 1516	Reeb graphs, Mapper
Apr 16	RT 403	Mapper
Apr 21	RT 1516	Hierarchical clustering, persistent homotopy, higher homotopy
Apr 23	RT 403	Project
Apr 28	RT 1516	Presentations
Apr 30	RT 403	Presentations
May 5	RT 1516	Feedback