

CS 599: The Geometry of Polynomials in Algorithms

Syllabus

Fall 2026

1 General Information

Instructor: Nathan Klein (nklei1@bu.edu)

Webpage: <https://nathan-klein.github.io/polynomials>

Lectures: Tuesday and Thursday, 3:30 - 4:45 in CAS 320

Office Hours: Monday 3 - 4:30, Thursday 2 - 3:30, and by appointment, in CDS 1026

Course Description: The starting point of the field is to encode combinatorial objects as multivariate polynomials. Typically, we will encode discrete probability distributions. For example, the distribution over $\{e, f\}$ which selects $\{e\}$ with probability $1/2$ and $\{e, f\}$ with probability $1/2$ is encoded as $p(x, y) = \frac{1}{2}x + \frac{1}{2}xy$. We will then analyze the zero-free regions of these polynomials in $\mathbb{C}^n$. These regions often have underlying geometry, hence the name of the course. We will study how this geometry can help us understand the original combinatorial object.

We will discuss some important recent results that use ideas from this field, such as the resolution of the Kadison-Singer problem, Mason's conjecture, and a slightly improved approximation for metric TSP.

Prerequisites: Strong undergraduate-level familiarity with probability, multivariable calculus, linear algebra, and a little analysis. Mathematically mature undergraduates are welcome.

2 Coursework

Grade Calculation: Homework (20%), assigned lecture and participation (20%), quizzes (20%), and a final project (40%).

Homework: There will be three or four homework assignments. Group work is encouraged, but write up your solutions alone and put the names of your collaborators on your submission. Please print out homework and bring it to class. If this is not possible due to special circumstances on the day of, it can be emailed to me, but please limit your use of this option.

Late Homework: You have four late days to use however you want between the homework sets. After that, late homework won't be accepted.

Assigned Lectures and Participation: Each student will be assigned one or two lectures (depending on the number of registered students) for which they are required to help write and proofread

the lecture notes, and ask a few questions during lecture. If being required to ask questions makes you too uncomfortable, please let me know and we can discuss an alternative. Students may elect to help present the material on their assigned day, but are not required to. This accounts for roughly half of your participation grade, the remainder comes from attending class.

Quizzes: There will be four quizzes. The quizzes will be based on flash cards that I post online and will contain basic definitions from the course. They will involve briefly explaining concepts from the flashcard deck, and then will typically have one additional question that requires some straightforward computation. This is designed to help students follow lectures. Learning math is like learning a language, and it is important to know the basic building blocks by heart.

Final Project: The final project will involve either undertaking an original research project or reading a paper in the field. There will be both a written component and a presentation at the end of the course. Projects may be done alone or in small groups. Students will need to discuss and clear their final project topic with me. If students want to continue working after the course to develop a project into a paper, I am happy to help make this happen in any way I can.

3 Additional Information

Piazza: We will be using Piazza: <https://piazza.com/bu/fall2026/ce15>. Consider posting questions here instead of emailing me, as this way all students can benefit.

Anki: I will post flashcards on the course website of definitions to know for the quizzes and, more importantly, to know so that it is easier to follow lectures.

Health: Please let me know if you are struggling at all with health issues and I am more than happy to help make the course more manageable for you. For mental health, consider [Student Health Services](#) as a resource: they provide free assessments and can help connect you to a therapist covered by your healthcare. They also run meditation sessions and support groups, with one explicitly aimed at graduate students.