MATH 7337 Syllabus

Harmonic Analysis, 3 credit hours

Fall 2026

Location: College of Computing, room 53
Time: TR 3:30pm-4:45pm

Instructor Information

Instructor: Galyna Livshyts

Office: 108C

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Office Hours: MW 11am-12:15pm

General Course Information

Description

This course is a graduate introduction to harmonic analysis and some of its most exciting modern applications. The course studies Fourier analysis on the torus and on Euclidean space. Core topics include Fourier series, L^1 and L^2 theory, approximate identities, completeness of exponentials, Weyl equidistribution, convergence of Fourier series, duality between smoothness and decay, L^p theory including the Hausdorff–Young Theorem, and the Fourier transform together with its applications. Additional topics include Poincaré inequalities and spherical harmonics, uncertainty principles, Fourier transforms in high dimensions and convexity.

Prerequisites and Scheduling

Prerequisite: MATH 6337 and MATH 6338

Lecture hours: 3

Lab hours: 0

Recitation hours: 0

Total credit hours: 3

Course Learning Outcomes

Upon successful completion of this course, students should be able to:

- work fluently with Fourier series on the torus and Fourier transforms on Euclidean space;
- apply the core L^1, L^2, and L^p tools of harmonic analysis in concrete examples and proofs;
- understand the role of approximate identities, convergence phenomena, and duality between smoothness and decay;
- use classical results such as the Hausdorff–Young Theorem and related estimates in appropriate settings;
- connect Fourier-analytic methods to applications involving distributions, measures, Sobolev spaces, and uncertainty principles;
- read, write, and communicate rigorous graduate-level proofs in harmonic analysis.

Required Course Materials

The following books provide background and supplementary reading for the course:

- Y. Katznelson, *An Introduction to Harmonic Analysis*, 3rd ed., Cambridge University Press, 2004.
- C. Muscalu and W. Schlag, *Classical and Multilinear Harmonic Analysis*, Vols. I–II, Cambridge University Press, 2013.
- S. Robins, *Fourier Analysis on Polytopes and the Geometry of Numbers: Part I: A Friendly Introduction*, American Mathematical Society, 2024.
- A. Koldobsky, *Fourier Analysis in Convex Geometry*, American Mathematical Society, 2005.
- H. Groemer, *Geometric Applications of Fourier Series and Spherical Harmonics*, Cambridge University Press, 1996.
- R. O'Donnell, *Analysis of Boolean Functions*, Cambridge University Press, 2014.
- T. W. Körner, *Fourier Analysis*, Cambridge University Press, 1988.
- L. Grafakos, *Modern Fourier Analysis*, 3rd ed., Springer, 2014.
- G. Travaglini, *Number Theory, Fourier Analysis and Geometric Discrepancy*, Cambridge University Press, 2014.
- C. Demeter, *Fourier Restriction, Decoupling, and Applications*, Cambridge University Press, 2020.
- F. Dai and Y. Xu, *Approximation Theory and Harmonic Analysis on Spheres and Balls*, Springer, 2013.
- C. Müller, *Spherical Harmonics*, Springer, 1966.

Additional reading, lecture notes, and supplementary references may be assigned or recommended during the semester.

Topic Outline

The course will cover the following topics:

- Fourier series.
- L^1 and L^2 theory.
- Approximate identities, completeness of exponentials, and Weyl equidistribution.
- Convergence of Fourier series.
- Duality between smoothness and decay.
- L^p theory, including the Hausdorff–Young Theorem.
- The Fourier transform and its applications.
- Poincaré inequalities and spherical harmonics.
- Uncertainty principles.
- Fourier transforms in high dimensions with applications.

Grading Policy

Final grades will be based on a combination of homework, 3 quizes, a midterm, a short in-class presentation on a pre-assigned topic, and a final creative writing assignment. The Quiz score will be based on the two best quiz scores out of three. Any adjustments to the grading scheme will be announced in class and posted on Canvas.

Assignments

- Homework: 30%
- 3 Quizes: 20%
- Midterm exam: 30%
- Short in-class presentation: 10%
- Final creative mathematical writing assignment: 10%

Letter grades will be assigned according to standard cutoffs.

Description of Graded Components

- **Homework:** Students are expected to write complete and mathematically rigorous solutions. Homework will be assigned throughout the course, with each problem rated from 1 to 5 points in difficulty. Students will be free to select a subset of these problems amounting to a total of 15 points for the course.
- **Quizes:** There will be 3 in-class Quizes focused on fostering skills required in the AI-era of Mathematics: determining errors in mathematical proofs, asking good mathematical questions, and quality written presentation. Quizes will be anounced at least a day prior to the date of administration. The Quiz score will be based on the two best quiz scores out of three.
- **Midterm exam:** The midterm will take place in person on November 17 and will be heavily based on the homework problems.
- **Presentation:** A short 15-minute presentation on a pre-assigned topic at some point during the semester.
- **Final writing assignment:** The final component will emphasize synthesis of major themes from the course, where students will need to write a clear presentation of some of the in-class concepts. AI use is allowed, and the assignment will be judged on originality and the quality of writing.

Course Policies

Attendance and Participation

Regular attendance is expected. Because this is a proof-based graduate course, much of the learning happens through active engagement with definitions, examples, and arguments developed during class. Students who miss class are responsible for obtaining notes, announcements, and assignments from Canvas or from classmates.

Participation may include asking questions, contributing to discussions, and, where appropriate, presenting solutions or reading assignments. Students should notify the instructor as soon as possible in the event of a serious illness, an Institute-approved absence, or another significant circumstance affecting attendance.

Communication

Course announcements, assignments, and other materials will be distributed through Canvas. Students are responsible for monitoring Canvas and their Georgia Tech email regularly.

Academic Integrity

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. Review Georgia Tech's Honor Code and the student Code of Conduct.

Collaboration on general ideas may be permitted on homework unless otherwise stated, but each student must write up and submit their own independent solutions. Any use of outside sources must be acknowledged clearly. Any student suspected of cheating or plagiarism on a quiz, exam, or assignment will be reported to the Office of Student Integrity, which will investigate the incident and identify the appropriate penalty for violations.

Accommodations for Students with Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services (404-894-2563) as soon as possible to make an appointment to discuss your needs and obtain an accommodations letter. Please also email me as soon as possible so that we can arrange a time to discuss your learning needs.

Student-Faculty Expectations Agreement

At Georgia Tech, we believe that it is important to strive for an atmosphere of mutual respect, acknowledgment, and responsibility between faculty members and the student body. The Student-Faculty Expectations articulate some basic expectations that you can have of me and that I have of you. In the end, respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, I encourage you to remain committed to the ideals of Georgia Tech while in this class.