

640:495 Special Topics ‘AI tools for mathematics’, Section 01

Instructor: Lisa Carbone, Professor of Mathematics (Algebra group),

Member of the AI Lab at Stevens Institute of Technology, ‘Trusted Tester’ for Google Gemini.

e-mail address: lisa.carbone@rutgers.edu

Office Hours: By appointment

Course Description

This section will explore the intersection of artificial intelligence, formal mathematical reasoning and computation, with a focus on concepts from linear algebra, graph theory and number theory. Topics include using Large Language Models (LLMs) for advanced mathematics, prompt engineering for mathematical tasks, verification of AI-generated output for mathematical proofs, mathematical proofs using the formal proof assistant Lean 4. We also explore the integration of LLMs with Computer Algebra Systems and SMT solvers.

The approximate sequence of topics is:

- Onboarding with AI, the structure and function of LLMs
- Prompt engineering for mathematics
- Computer algebra systems
- Paradoxes: Naive set theory to ZFC set theory, Introduction to Type Theory
- The formal proof assistant Lean
- Writing Lean code for theorem proving: Natural numbers, Real numbers
- Interactive research with LLMs and Lean
- SMT solvers and hybrid proof assistants

In-class interactive exercises will involve using AI to generate executable code. Subject matter will be drawn from elementary number theory, graph theory and cryptography.

Assessment

Assessment will be based on class participation, and two projects, a midterm project and an end of semester project, both to be delivered by class presentation. Relevant homework assignments will be given. These will not be graded, but will be counted for and relevant to participation in class.

Class Participation (10%): Active engagement in discussions, contributions to in-class activities, and questions regarding course material and LLM interactions.

Mid-Semester Project (40%): A project possibly focusing on AI driven formalization and verification of mathematical concepts.

End-of-Semester Project (40%): A more comprehensive project (or continuation of the previous project) allowing for deeper exploration of an LLM-related topic in mathematics, potentially involving advanced formalization.

Technology requirements:

A laptop will be required for each class to be used for reading, implementing AI and programming.