Computer Assisted Formalization of Mathematics

Listed as
DS-GA 3001 007: Special Topics in Data Science
MATH-GA 2650: Adv. Topics in Analysis

Syllabus

Semester: Fall 2026

Instructor: Jaume de Dios
Class Location: 12 Waverly Pl Room L120
Lecture Meeting Day(s) and Time: Wednesdays 10:15 - 12:15
Email: jdedios@nyu.edu
Office Hours and Location: Tuesdays 16h-17h, 60 5th Ave, Office 615

TA: Niket Patel
Recitation Location: Tisch Hall (40 W 4th St), Room LC9
Recitation Meeting Day(s) and Time: Thursdays 11:15am-12:05pm
Email: nnp5656@nyu.edu
Office Hours and Location: TBD

Number of Credits:
This 3-credit course will meet for a lecture with the instructor once per week for 120-minutes each for 14 weeks. Outside of the lecture, students will also participate in 50-minute recitations led by the section leader for 14 weeks.

Prerequisites or Co-requisites

- Students should have familiarity with programming in some programming language.
- Students should be able to perform basic operations in git. This can be learnt during the first week but will not be taught in class.
- Students must be comfortable with the concept of a mathematical proof, and able to write down basic mathematical proofs. This includes:
    - Understanding and familiarity with logical statements (for-all, exists, negation, inclusion…) and their operations.
    - The ability to write/structure a proof using the elementary techniques, such as *by induction, by contradiction...*
    - Elementary proof-based calculus (derivatives, integrals, limits) and linear algebra (rank-nullity, determinants).

Course Website: https://nyulean26.github.io/

Course Description

This course introduces the principles and practice of computer-assisted proof formalization using the Lean 4 proof assistant. Students will learn how to rigorously encode mathematical definitions, statements, and proofs in Lean, enabling machine-checked verification of correctness. Along the way, the course develops an understanding of the logical and type-theoretic foundations underlying Lean, including dependent type theory and the structure of modern formal mathematical libraries such as Mathlib. In the later part of the course, students will explore recent advances in AI-assisted formalization, focusing on techniques for proof search and automatically translating informal mathematical arguments into formal proofs.

Learning Outcomes

- **Read, write and debug Lean4 code** including assessing definitions and theorem statements, writing proofs, and understanding the elements of Lean syntax and associated semantics.
- **Understand the logical and type-theoretic principles underlying Lean.** Including propositions-as-types, dependent types, universes, inductive types.
- **Translate informal mathematical and logical statements** into Lean, and critically construct machine-checkable statements and proofs of those statements, and debug and assess statements produced by others.
- **Use Lean libraries effectively,** locating relevant definitions, understanding common abstraction patterns, and adapting existing libraries and results to new formalization tasks.
- **Understand Lean's extensibility mechanisms,** such as metaprograming concepts, including the implementation of simple tactics.
- **Evaluate AI-assisted theorem proving methods and their outcomes critically.**

Course Requirements (Instructional Time and Supplemental Time)

Time on Task Type	Activity	Time (total for course)
Instructional Time	Synchronous lecture, once per week for 14 weeks, 120 minutes	1680 minutes
Instructional Time	Synchronous recitation once per week for 14 weeks, 50 minutes	700 minutes
Supplemental Time	Quiz Preparation	600 minutes
Supplemental Time	Final Project	2100 minutes
Supplemental Time	Homework assignments	1800 minutes

Schedule of Classes (Weekly Schedule)

Week	Topic (tentative)	Week	Topic (tentative)
1	Intro to Lean The Natural Numbers Game	8	Executable code in Lean, Monads
2	Propositions as types, Proof terms Some proofs in combinatorics	9	Proofs about code, introduction to Hoare logic.
3	Dependent types, Definitional equality Universes & Polymorphism	10	Lean under the hood, axioms and the trust surface of Lean
4	Induction and inductive types Proofs with inductive data	11	Metaprogramming in Lean
5	Structures, Typeclasses and Inheritance	12	Proof automation, certificates and proofs by reflection
6	Mathlib & Lean libraries Algebraic structures in Lean	13	Agentic Lean proof generation I
7	Elementary analysis and optimization in Lean	14	Agentic Lean proof generation II

The TA session may be split for the last five weeks 10-14, so that students interested in Mathematics can learn about advanced mathematics in Lean (topology, measure theory…), while students in Data Science can learn about modern AI4Lean tooling (automatic search for proofs, reinforcement learning…)

Assignments

Quizzes: 40%. Four quizzes administered during the weeks 3,5,7,9 in the TA session, each taking ~20 minutes to complete.
Homework: 20%: Submitted through Gradescope at the end of weeks 2,4,6,8. Covering the topic of the recitation and preparing you for the quizzes.
Final Project: 40%. Time permitting, depending on the number of students enrolled/number of group projects, a final presentation will be given.

Required Course Materials

Students will need a laptop able to run VSCode and Lean.

Recommended Readings and Resources

The class will draw from a family of books available online, and their corresponding Lean worksheets.

Mathematics in Lean (MiL) *by Jeremy Avigad and Patrick Massot*
Theorem Proving in Lean (TPiL) *by Jeremy Avigad, Leonardo de Moura, Soonho Kong, Sebastian Ullrich, with contributions from the Lean Community*
Functional Programming in Lean (FPiL) *by David Thrane Christiansen*
Metaprogramming in Lean (MPiL) *by Arthur Paulino, Damiano Testa, Edward Ayers, Evgenia Karunus, Henrik Böving, Jannis Limperg, Siddhartha Gadgil, Siddharth Bhat*

Students may find the following two resources valuable

The Mechanics of Proof *by Heather Macbeth*

The Hitchhiker's Guide to Logical Verification, 2026 edition (LoVe) *by Anne Baanen, Alexander Bentkamp, Jasmin Blanchette, Xavier Généreux, Johannes Hölzl, Jannis Limperg*

Grading

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Homework: 20%: Submitted through Gradescope at the end of weeks 2,4,6,8. Covering the topic of the recitation and preparing you for the quizzes.
Final Project: 40%. Time permitting, depending on the number of students enrolled/number of group projects, a final presentation will be given.

Basis of Final Grade Determination

These letters represent a *minimum guaranteed grade*, i.e. Students obtaining a 90% will obtain at least an A-. In exceptional circumstances the lecture may lower the thresholds for a given grade.

Numerical Grade	Letter Grade
90% - 100%	A-/+
80% - 90%	B-/+
65% - 80%	C-/+
50% - 65%	D-/+

Course Policies

- **Attendance and Tardiness:** Attendance to the lectures is encouraged but not required in any form. Quizzes will be delivered in person only.
- **Religious Observance:** New York University seeks to maintain a welcoming and equitable environment for students with diverse religious, spiritual, or similarly organized ethical belief systems and backgrounds. As a nonsectarian institution, NYU adheres to the general policy of including in the official calendar of the University only certain legal holidays. In a commitment to the spirit of pluralism, in compliance with New York State law, and as a matter of long-standing University policy, students may, without penalty, excuse themselves from academic obligations and otherwise receive a reasonable accommodation when required for religious and spiritual holidays and observances, as defined and set forth in this policy.
- **Late Assignments:** A make-up session for any missed quizzes will be held on Week 10. Students must notify the instructor in writing no later than the end of Week 9 about any quizzes they have missed and they wish to take during Week 10. Late submission of the final project is not permitted.
- **Academic Honesty:** NYU students and faculty are expected to maintain the highest standards of academic honesty. Students can find information on the core principles and standards in the University's policy on academic integrity.
- **Artificial Intelligence Statement:**
  Weeks 1-8 are focused on the basics of the Lean Language. During this time, no submitted material (homework) may be AI generated. For the purposes of homework, the usage of AI-as-a-tutor is discouraged (in favor of discussions with your peers) but not prohibited.
  From week 9 on (when preparing the final project) the usage of Generative AI is allowed, and encouraged. Students must disclose the usage of generative AI for the final project in a detailed manner. The amount of AI assistance will not be used to determine the grade of the project, but students are expected to be able to engage with any part of the project/codebase with proficiency equivalent to if it was written by them.

Student Accessibility

New York University is committed to providing equal educational opportunity and participation for students of all abilities. We work with NYU students to determine appropriate and reasonable accommodations that support equal access to a world-class education. Students requesting academic accommodations are advised to reach out to the Moses Center for Student Accessibility as early as possible in the semester for assistance.

Moses Center for Accessibility and Inclusive Culture
Telephone: 212-998-4980
Website:
https://www.nyu.edu/life/community-flourishing/centers-and-communities/accessibility.html
Email: mosescenter@nyu.edu

Student Wellness

In a large, complex community like NYU, it's vital to reach out to others, particularly those who are isolated or engaged in self-destructive activities. Student wellness is the responsibility of all of us.

The NYU Wellness Exchange is the constellation of NYU's programs and services designed to address the overall health and mental health needs of its students. Students can access this service 24 hours a day, seven days a week - wellness.exchange@nyu.edu; (212) 443-9999. Students can call the Wellness Exchange hotline (212-443-9999) or the NYU Counseling Service (212-998-4780) to make an appointment for Single Session, Short-term, or Group counseling sessions.