Benjamin Singer
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Education

- Dartmouth College, Hanover, New Hampshire, September 2023 - Present
    - B.A. candidate in Mathematics and Music
    - Cumulative 3.93 GPA, 3.98 Mathematics GPA, 4.0 Music GPA

Interests

- Arithmetic Geometry
    - p-adic Hodge Theory
    - Brauer Groups and Obstructions to Rational Points
    - Computational Aspects

Research

- *Derived Relative Geometry, with Applications to Complex Geometry*, with Arun Soor (in preparation)
    - Gave a talk in the Michigan REU Seminar, listed below
- *A Geometric Approach to Magic Squares of Squares*, with Asher Auel (in preparation)
    - Presented a poster on progress at 2024 AGNES at Dartmouth poster session (AGNES Homepage - Dartmouth 2024, Dartmouth Hosts Major Algebraic Geometry Conference | Faculty of Arts and Sciences)
    - Gave a talk at the Young Mathematicians Conference, listed below
- *Strata of Toric Hyperplane Arrangements, Zonotope Lattice Points, and the Bondal-Thomsen Collection.* With Friedrich Bauermeister, Andrew Hanlon, Davis Painter, and Sair Shaikh (arxiv: [2507.14356]), to appear in *Involve*. Result of 2024 SHUR at Dartmouth: SHUR | Dartmouth College
    - Gave a talk on results and necessary background information in the Dartmouth Algebra and Number Theory Seminar, listed below

Teaching

- Fall 2025 - Undergraduate Teaching Assistant, Math 101: Linear and Multilinear Algebra
    - Alongside the roles I have held in my other teaching assignments, I also gave a 10-lecture mini course on introductory category theory. Notes from the proceedings are below.
- Spring 2025 - Undergraduate Teaching Assistant, Math 19: Intro Set Theory
    - Held weekly office hours, held exam review sessions, & proctored midterm exams
    - Textbook: Enderton - *Elements of Set Theory*
- Winter 2025 - Undergraduate Teaching Assistant, Math 81/111: Abstract Algebra
    - Graded homework, held weekly office hours, & held exam review sessions

    - Textbooks: Milne - *Fields and Galois Theory*, Milne - *Algebraic Number Theory*
- Fall 2024 - Undergraduate Teaching Assistant, Math 71: Algebra
    - Graded homework, held weekly office hours, & held exam review sessions
    - Textbook: Dummit & Foote - *Abstract Algebra, Third Edition*
- Spring 2024 - Undergraduate Teaching Assistant, Math 24: Linear Algebra
    - Graded homework, held weekly office hours, & held exam review sessions
    - Textbook: Friedberg, Insel, & Spence - *Linear Algebra, Fifth Edition*

Mentorship

- Spring 2026 - Mathematics Department Directed Reading Program, advanced undergraduate student mentor - Category Theory
    - Students - Henry Dorr, Sean Kim, Idil Sahin
    - Meeting once per week with mentees for 10 weeks, with 1.5 hours of lecture and discussion.
    - Textbooks: Riehl - *Categories for the Working Mathematician*, my notes (below)
- Winter 2026 - Mathematics Department Directed Reading Program, advanced undergraduate student mentor - Galois Cohomology
    - Students - Frank Gallo, Michael Kalinichenko, Sair Shaikh, Aidan Hennessey, Semir Mujevic
    - Meeting once per week with mentees for 10 weeks, with 1.5 hours of lecture and 30 minutes of discussion per session. 10 lectures in total
    - Textbooks: Gille and Szamuely - *Central Simple Algebras and Galois Cohomology*, Serre - *Local Fields*
    - Notes in progress!
- Summer 2025 - Undergraduate student mentor on Homological Algebra, unofficial
    - Students - Ribhu Hooja and Frank Gallo
    - Met twice per week with two undergraduate student mentees. Gave an hour-long lecture each session, then discussed material and worked on/assigned problems, wrote problem sets to cover further examples and extra material. 20 lectures in total
    - Textbooks: Dummit and Foote - *Abstract Algebra.* Weibel - *An Introduction to Homological Algebra.*
    - Course doc here:
      Summer 2025 Homological Algebra Reading Course Syllabus
    - Notes available below
- Winter 2025 - Mathematics Directed Reading Program, advanced undergraduate student mentor - Category Theory and Further Mathematical Abstraction (Directed Reading Program)
    - Student - Liam Nokes
    - Met weekly with undergraduate student mentee to discuss material & work on/assign problems, wrote several problem sets to cover further examples and extra material
    - Textbook: MacLane, *Categories for the Working Mathematician*

Expository Notes

- I wrote a survey paper on GAGA-type theorems and their applications in analytic and algebraic geometry for my final project in the Hodge theory topics course I took in Spring 2025, available here.
- Attached here are the notes from the homological algebra DRP I oversaw: Homological Algebra.pdf. These are still in development, so far covering:
  - Projective, injective, and flat resolutions
  - Derived functors
  - Ext and Tor (including the Baer sum, Kunneth formulae, etc)
  - Applications to commutative algebra (Hilbert's syzygy theorem, discussion of local rings via homological dimension, and the Quillen-Suslin theorem)
  - Exercises
- Attached here are the notes from the category theory minicourse I taught: Categories.pdf. These are still in development, so cover:
  - Categories, functors, and natural transformations
  - Duality and opposites
  - Functor categories
  - The Yoneda lemma and representability
  - Universal properties, (co)limits
  - Existence of (co)limits, preservation of limits, and (co)completeness
  - Abstract categorical axiomatization of algebraic structure
  - Adjoint functors and interactions with (co)limits
  - Abelian categories and applications of category theory to homological algebra
  - Exercises

Invited Lectures

- University of Michigan REU Seminar (2026 UM REU Seminar), Tuesday, July 7, 2026, Ann Arbor, Michigan
  - Talk Title: *Derived Analytic Geometry*
- Dartmouth Algebra and Number Theory Seminar (DANTS, Dartmouth College - Algebra and Number Theory Seminar), Tuesday, February 3, 2026, Hanover, New Hampshire
  - Talk Title: *An Introduction to p-adic Hodge Theory*
- Young Mathematicians Conference 2025 (Home | Young Mathematicians Conference)
  - Talk Title: *Magic Squares of Squares*
- Dartmouth Algebra and Number Theory Seminar, Tuesday, November 12, 2024, Hanover, New Hampshire
  - Talk Title: *The Bondal-Thomsen Collection of a Toric Variety*

Awards:

- Barry M. Goldwater Scholarship, $7500
- Francis L. Town Scientific Prize in Mathematics, class of 2027, $800
- Rufus Choate Scholar, Academic Year 2024-2025
- Jack Byrne Scholar in Mathematics, $20,000
- James O. Freedman Presidential Scholarship, $3,500

- Gerald A. Tracy Memorial Scholarship Prize for Piano, $300

Travel and Conferences:

- The Australian Direction, August 2026 (upcoming)
- International Congress of Mathematicians, July 2026 (upcoming)
- Algebraic Geometry Northeastern Series, May 2026
- Dartmouth-UVM Math Day, April 2026
- Summer Research Institute in Algebraic Geometry 2025, July 2025 (virtual)
- Young Mathematicians Conference 2025, July 2025 (in-person)
    - Gave an invited talk (details above)
- The Legacy of John Tate and Beyond, March 2025 (virtual)
- Algebraic Geometry Northeastern Series at Dartmouth, November 2024 (in-person)
    - Presented poster at poster session (details above)

Relevant Coursework

Given in reverse chronological order. All courses with a number above 100 are at the graduate level, and all courses with two numbers are dual-listed advanced undergraduate/graduate courses. Included are further descriptions of reading courses and graduate topics courses I have taken, which often have names on my transcript that do not accurately describe what was covered (e.g. Math 121 - Current Problems in Algebra).

I have been an active participant and lecturer in Math 150, Graduate Subject Seminar, every term it has been offered since the Winter of 2024. I have only been able to elect it for credit starting from Fall 2025 due to limits on the number of courses the registrar allows me to take for credit during each term and, more generally, my time at Dartmouth. Details on my talks are given in this section.

- Spring 2026:
    - Math 121: Current Problems in Algebra - Combinatorial Algebraic Geometry
        - Taught by Juliette Bruce
        - Textbook: Cox, Little, & Schenck: *Introduction to Toric Varieties*
    - Math 87: Reading Course - Integral p-adic Hodge Theory
        - Overseen by Salim Tayou
        - Textbook/Reference: Kisin - *Crystalline Representations and F-Crystals*, Brinon & Conrad - *CMI Summer School Notes on p-adic Hodge Theory,* Ch. 10-16
    - Math 113: Analysis - Graduate Complex Analysis
        - Taught by Dana Williams
        - Textbook: Williams - *My Complex Analysis Course*
- Winter 2026:
    - Math 124: Current Problems in Topology - on Heegard-Floer Homology and Low-dimensional Topology:
        - Taught by Abhishek Mallick

    - Math 87: Reading Course - Introduction to p-adic Hodge Theory
        - Overseen by Salim Tayou
        - Textbook: Fontaine & Ouyang - *Theory of p-adic Galois Representations*, Brinon & Conrad - *CMI Summer School Notes on p-adic Hodge Theory*, Ch. 1-9
    - Math 150: Graduate Subject Seminar
        - Learning Seminar Topic: The Weil Conjectures
            - Gave a talk on Deligne's proof of the Riemann hypothesis (cf. Deligne - *La Conjecture de Weil I, La Conjecture de Weil II*)
            - Gave a talk on motives and the standard conjectures (cf. Kleiman - *The Standard Conjectures)*
- Fall 2025:
    - Math 73/103: Metric Spaces and Measure Theory
        - Taught by John D. Trout
        - Textbooks: Royden & Fitzpatrick, *Real Analysis*, Ch. 9-10, Folland, *Real Analysis,* Ch. 1-2, 6
    - Math 150: Graduate Subject Seminar
        - Learning Seminar Topic: Abelian Varieties
            - Gave a lecture on the Hodge-Tate decomposition for abelian varieties over p-adic fields (cf. Tate - *p-divisible Groups*)
- Spring 2025:
    - Math 121: Current Problems in Algebra - Hodge Theory
        - Taught by Salim Tayou
        - Textbooks: Voisin - *Hodge Theory and Complex Algebraic Geometry I*, Griffiths & Harris - *Principles of Algebraic Geometry*
    - Math 151 - Graduate Special Topics - on Mathematics Pedagogy
        - Taught by Merve Kursav
    - Math 148 - Independent Project - Mathematics Teaching Practicum:
        - Teaching Practicum "course within a course" on public key cryptography, taught by Asher Auel and designed by me, Michaela Polley (first year PhD), Will DeGroot (2nd year PhD), and Ben Shapiro (2nd year Masters)
        - Gave three lectures on elliptic curve discrete log problems, the Weil Pairing, and the MOV Algorithm
- Winter 2025:
    - Math 104: Differential Topology
        - Taught by Ina Petkova
        - Textbooks: Lee - *Introduction to Smooth Manifolds,* Bott & Tu - *Differential Forms in Algebraic Topology*
    - Math 87: Reading Course - Commutative Algebra
        - Overseen by Asher Auel
        - Textbooks: Matsumura - *Commutative Ring Theory*, Atiyah & MacDonald - *Introduction to Commutative Algebra*
    - Math 150: Graduate Subject Seminar (Audited)
        - Learning Seminar Topic: Assorted Topics in Arithmetic Geometry

                - Gave a lecture on l-adic Galois representations over global and local fields
                - Gave a lecture on etale cohomology
- Fall 2024:
    - Math 101: Linear and Multilinear Algebra
        - Taught by Asher Auel
        - Textbooks: Lang - *Algebra*, Dummit & Foote - *Abstract Algebra*
    - Math 87: Reading Course - Classification of Algebraic Surfaces
        - Overseen by Tristan Phillips
        - Textbooks: Beauville - *Complex Algebraic Surfaces*, Hartshorne - *Algebraic Geometry*, Ch. 5
    - Math 150: Graduate Subject Seminar (Audited)
        - Learning Seminar Topic: Assorted Topics in Algebraic Geometry
            - Gave a lecture on Grassmannian and flag varieties
- Spring 2024:
    - Math 115: Number Theory - on Galois Cohomology and Brauer Groups of Fields
        - Taught by Asher Auel
        - Textbooks: Gille & Szamuely - *Central Simple Algebras and Galois Cohomology*, Serre - *Galois Cohomology*
    - Math 74/114: Algebraic Topology
        - Taught by Vladimir Chernov
        - Textbooks: Allen Hatcher - *Algebraic Topology*, Chapters 1-3
- Winter 2024:
    - Math 81/111: Abstract Algebra - Field and Galois Theory
        - Taught by Asher Auel
        - Textbooks: Dummit & Foote - *Abstract Algebra*
    - Math 150: Graduate Subject Seminar (Audited)
        - Learning Seminar Topic: Elliptic Curves
        - Gave a lecture on modular curves and the modularity theorem
- Fall 2023:
    - Math 71: Algebra - Honors Group and Ring Theory
        - Taught by Asher Auel
        - Textbook(s): Dummit & Foote - *Abstract Algebra*

Independent Mathematics Study

I have studied several topics in mathematics in my free time throughout my undergraduate studies, which I have then applied in my research, teaching, and coursework. My choices for this reading have been guided by advice and book recommendations from Asher Auel, Salim Tayou, and John Voight. This independent study explains many of the jumps in my official coursework. Here is a chronological list of what I have covered:

- Spring 2026: Six Functor Formalisms
    - Reading - Scholze - *Six Functor Formalisms*

- Spring 2026: Simplicial Homotopy Theory and Higher Category Theory
    - Reading - Goerss-Jardine - *Simplicial Homotopy Theory,* ch. 1-3, Cisinski - *Higher Categories and Homotopical Algebra,* ch. 1-7
- Fall 2025: p-divisible Groups and Dieudonne Theory
    - Continued reading under Salim Tayou to prepare for winter and spring readings on p-adic Hodge theory
    - Reading - Tate - *p-divisible Groups*, Grothendieck - *Groupes de Barsotti-Tate et Cristaux de Dieudonne*
- Summer 2025: Variations of Hodge Structure and Algebraic Groups
    - Structured as reading under Salim Tayou to supplement ongoing research.
    - Reading - Voisin - *Hodge Theory and Complex Algebraic Geometry II*, ch. 1-5. Milne - *Algebraic Groups*
- Summer 2025: Class Field Theory
    - Structured as reading course under Salim Tayou to supplement ongoing research
    - Reading - Serre - *Local Fields*, Cassels & Frohlich - *Algebraic Number Theory,* Ch. 7
- Winter 2025: Complex Analysis
    - Reading - Stein & Shakarchi - *Complex Analysis*
- Fall 2024-Winter 2025: Brauer Groups in Algebraic Geometry
    - Reading - Colliot-Thélène & Skorobogatov - *The Brauer-Grothendieck Group*
        - Reading supplemented ongoing research
- Fall-Winter Break 2024: Derived Categories in Algebraic Geometry
    - Reading - Huybrechts - *Fourier-Mukai Transforms in Algebraic Geometry*, assorted papers of Kuznetsov, Caldararu, Bondal, and Orlov
        - Reading supplemented preparation for DANTS talk
- Winter Break 2024: Algebraic Number Theory
    - Reading - Neukirch - *Algebraic Number Theory*, Ch. 1-2
- Summer-Fall 2024: Sites and Étale Cohomology
    - Reading - Milne - *Lectures on Étale Cohomology*, Part 1
- Summer-Fall 2024: Homological Algebra
    - Reading - Weibel - *An Introduction to Homological Algebra*, Ch. 1-4, 7, 9
    - Other chapters cover material I have learned in my coursework (derived functors, group cohomology, simplicial objects/geometric realization)
- Summer 2024: Scheme Theory and Sheaf Cohomology
    - Audited graduate reading course overseen by Asher Auel
    - Reading - Hartshorne - *Algebraic Geometry*, Ch. 2-3
- Fall 2023-Winter 2024: Category Theory
    - Reading - MacLane, *Categories for the Working Mathematician*, Ch. 1-5, 7-8, 10, Riehl - *Category Theory in Context*
- Fall 2023: Point-Set Topology
    - Reading - Munkres, *Topology*, Ch. 1-5

Service Outside Mathematics

- Dartmouth Powerlifting Team, president, September 2025 - Present
- Senior New Student Orientation Leader, March 2025 - September 2025
- Dartmouth Powerlifting Team, co-captain, September 2024 - September 2025
- Dartmouth Student Mental Health Union, co-president, April 2024 - December 2024
- New Student Orientation Leader, August-September 2024