

 0000-0001-9152-2477 •
  molnar.grant.5772@gmail.com
 www.grantmolnar.com •
  github.com/grantmolnar

Education

PhD, Mathematics, *Dartmouth College*, Hanover, NH Fall 2018 - Spring 2023

Advisor: John Voight

Thesis: *Counting elliptic curves with a cyclic m -isogeny over \mathbb{Q}*

MA, Mathematics, *Dartmouth College*, Hanover, NH Fall 2018 - Winter 2020

Advisor: John Voight

MS, Mathematics, *Brigham Young University*, Provo, UT Winter 2017 - Summer 2018

Advisors: Michael Griffin and Paul Jenkins

Thesis: *The arithmetic of modular grids*

BS, Mathematics, *Brigham Young University*, Provo, UT Fall 2013 - Fall 2016

Professional Experience

Academic Researcher at BYU and Dartmouth Fall 2013 - Spring 2023

At BYU, I proved results about modular forms and algorithms on graphs. At Dartmouth, I instigated successful research into summing divergent series, the Prisoner's Dilemma, and the Ramanujan-Robin criterion. My thesis develops the arithmetic statistics of elliptic curves with cyclic m -isogeny. See Research Publications and Preprints below.

Math Instructor at BYU and Dartmouth Winter 2017 - Spring 2023

I taught 30-student calculus courses in three different styles: lecturing, virtually with a "flipped classroom", and with handouts and group exercises. I TAed for lower-division courses, and by special request for upper-division courses as well. See Teaching Experience below.

Computer Skills

Fluent in...

Bash • Git • Go • \LaTeX • Python • R • SageMath • YAML

Experience with...

C++ • gRPC • HTML • Magma • Mathematica • MatLab • MongoDB • PARI/GP • Rust

Books

Puzzle and Proof: A Decade of Problems from the Utah Math Olympiad, *with Samuel Dittmer, Hiram Golze, and Caleb Stanford*

AK Peters/CRC Recreational Mathematics Series.

This book is a collection of 70 mathematical problems and puzzles from the first ten years of the Utah Math Olympiad (UMO), 2013–2022. These problems are distinguished in two respects. First, they aim to be *understandable* to an advanced high school audience, even if solving them can sometimes be quite difficult. Second, all of the problems ask for not only an answer, but a *proof*.

Research Publications

Counting elliptic curves over the rationals with a 7-isogeny, with John Voight

Research in Number Theory **9**, 75 (2023). arXiv: 2212.11354

We count by height the number of elliptic curves over the rationals, both up to isomorphism over the rationals and over an algebraic closure thereof, that admit a cyclic isogeny of degree 7.

Reactive means in the Iterated Prisoner's Dilemma, with Caroline Hammond and Feng Fu

Applied Mathematics and Computation **458** 128201 (2023). arXiv: 2302.13909

The Iterated Prisoner's Dilemma (IPD) is a well studied framework for understanding direct reciprocity and cooperation in pairwise encounters. However, measuring the morality of various IPD strategies is still largely lacking. Here, we partially address this issue by proposing a suit of plausible morality metrics to quantify four aspects of justice. We focus our closed-form calculation on the class of reactive strategies because of their mathematical tractability and expressive power. We define reactive means as a tool for studying how actors in the IPD and Iterated Snowdrift Game (ISG) behave under typical circumstances. We compute reactive means for four functions intended to capture human intuitions about "goodness" and "fair play". Two of these functions are strongly anticorrelated with success in the IPD and ISG, and the other two are weakly anticorrelated with success. Our results will aid in evaluating and comparing powerful IPD strategies based on machine learning algorithms, using simple and intuitive morality metrics.

The arithmetic of modular grids, with Michael Griffin and Paul Jenkins

Mathematika **68**, 1080-1119 (2022). arXiv: 2012.14403

A modular grid is a pair of sequences $(f_m)_m$ and $(g_n)_n$ of weakly holomorphic modular forms such that for almost all m and n , the coefficient of q^n in f_m is the negative of the coefficient of q^m in g_n . Zagier proved this coefficient duality in weights $1/2$ and $3/2$ in the Kohnen plus space, and such grids have appeared for Poincaré series, for modular forms of integral weight, and in many other situations. We give a general proof of coefficient duality for canonical row-reduced bases of spaces of weakly holomorphic modular forms of integral or half-integral weight for every group $\Gamma \subseteq \mathrm{SL}_2(\mathbb{R})$ commensurable with $\mathrm{SL}_2(\mathbb{Z})$. We construct bivariate generating functions that encode these modular forms, and study linear operations on the resulting modular grids.

Odd, spoof perfect factorizations, with the BYU Computational Number Theory Group

Journal of Number Theory **234**, 31-47 (2022). Quanta article. arXiv: 2006.10697

We investigate the integer solutions of Diophantine equations related to perfect numbers. These solutions generalize the example, found by Descartes in 1638, of an odd, "spoof" perfect factorization $3^2 \cdot 7^2 \cdot 11^2 \cdot 22021^1$. More recently, Voight found the spoof perfect factorization $3^4 \cdot 7^2 \cdot 11^2 \cdot 19^2 \cdot (-127)^1$. No other examples appear in the literature. We compute all nontrivial, odd, primitive spoof perfect factorizations with fewer than seven bases – there are twenty-one in total. We show that the structure of odd, spoof perfect factorizations is extremely rich, and there are multiple infinite families of them. This implies that certain approaches to the odd perfect number problem that use only the multiplicative nature of the sum-of-divisors function are unworkable. On the other hand, we prove that there are only finitely many nontrivial, odd, primitive spoof perfect factorizations with a fixed number of bases.

Zagier duality for level p weakly holomorphic modular forms, with Paul Jenkins

The Ramanujan Journal **50**, 93–109 (2019). arXiv: 1709.10023

We prove Zagier duality between the Fourier coefficients of canonical bases for spaces of weakly holomorphic modular forms of prime level p with $11 \leq p \leq 37$ with poles only at the cusp at ∞ , and special cases of duality for an infinite class of prime levels. We derive generating functions for the bases for genus 1 levels.

Graphs with the strong Havel-Hakimi property, with Michael Barrus

Graphs and Combinatorics **32**, 1689–1697 (2016). arXiv: 1505.00085

The Havel–Hakimi algorithm iteratively reduces the degree sequence of a graph to a list of zeroes. As shown by Favaron, Mahéo, and Sacle, the number of zeroes produced, known as the residue, is a lower bound on the independence number of the graph. We say that a graph has the strong Havel–Hakimi property if in each of its induced subgraphs, deleting any vertex of maximum degree reduces the degree sequence in the same way that the Havel–Hakimi algorithm does. We characterize graphs having this property (which include all threshold and matrogenic graphs) in terms of minimal forbidden induced subgraphs. We further show that for these graphs the residue equals the independence number, and a natural greedy algorithm always produces a maximum independent set.

Research Preprints

Minimalist practical numbers

Submitted for publication.

A natural number n is practical if every smaller number can be written as a sum of distinct divisors of n . We say that a practical number n is minimalist if this representation is unique. In this note, we prove that a practical number is minimalist if and only if it is a power of 2.

A database of basic numerical invariants of Hilbert modular surfaces, with Eran Assaf, Angelica Babei, Ben Breen, Edgar Costa, Juanita Duque-Rosero, Aleksander Horawa, Jean Kiefer, Avinash Kulkarni, Sam Schiavone, and John Voight

Preprint. arXiv: 2301.10302

We describe algorithms for computing geometric invariants for Hilbert modular surfaces, and we report on their implementation.

Multiplicative summations into algebraically closed fields, with Robert Dawson

Preprint. arXiv: 2111.09938

In this paper, extending our earlier program, we derive maximal canonical extensions for multiplicative summations into algebraically closed fields. We show that there is a well-defined analogue to minimal polynomials for a series algebraic over a ring of series, the “scalar polynomial”. When that ring is the domain of a summation \mathfrak{S} , we derive the related concepts of the \mathfrak{S} -minimal polynomial for a series, which is mapped by \mathfrak{S} to a scalar polynomial. When the scalar polynomial for a series has the form $(t - a)^n$, a is the unique value to which the series can be mapped by an extension of the original summation.

Telescopic, multiplicative, and rational extensions of summations, with Robert Dawson

Preprint. arXiv: 2105.04592

A summation is a shift-invariant \mathbb{R} -module homomorphism from a submodule of \mathbb{R} to \mathbb{R} or another ring. Dawson formalized a method for extending a summation to a larger domain by telescoping. In this paper, we revisit telescoping, we study multiplicative closures of summations (such as the usual summation on convergent series) that are not themselves multiplicatively closed, and we study rational extensions as a generalization of telescoping.

Expository Notes

Fast-growing series are transcendental, with Robert Dawson

Unpublished. arXiv: 2102.12995

Let R be a subring of $\mathbb{C}[[z]]$, and let $X \in \mathbb{C}[[z]]$. The Newton-Puiseux Theorem implies that if the coefficients of X grow sufficiently rapidly relative to the coefficients of the series in R , then X is transcendental over R . We provide an alternative proof of this result by establishing a relationship between the coefficients of $A(X)$ and $A'(X)$, where $A(T)$ is a polynomial over $\mathbb{C}[[z]]$.

Manuscripts in Preparation

A family of analogues to the

Ramanujan-Robin criterion, with Steve Fan and Mits Kobayashi

Odd, spoof quasiperfect factorizations, with Jonathon Hales

Visualizing Basel's problem, with Mits Kobayashi

Selected Git Projects

Spoof Quasiperfect Factorizations

Fall 2021

<https://github.com/grantmolnar/Spoof-Quasiperfect-Factorizations>

Awards and Fellowships

Dartmouth Graduate Fellowship

Fall 2018 - Summer 2023

Gridley Fund for Graduate Mathematics

Fall 2018 - Summer 2019

NSF Graduate Research Fellowship Honorable Mention

April 2018

BYU Academic Scholarship

Spring 2015 - Winter 2016

BYU Math Department Scholarship

Fall 2016

BYU Math Department Scholarship

Fall 2015

BYU Academic Scholarship

Fall 2013 - Winter 2014

Teaching Experience

Dartmouth College, Hanover, NH (Instructor)

Math 8 (Calculus of One and Several Variables)

Fall 2021

Math 1 (Algebra and Calculus)

Fall 2020

Dartmouth College, Hanover, NH (Teacher's Assistant)

Math 100 / Computer Science 49/149 (Random Walk)

Spring 2022

Math 100 / Computer Science 49/149 (Decision Theory)

Spring 2021

Math 23 (Differential Equations)

Winter 2020

Math 3 (Calculus)

Fall 2019

Math 22 (Linear Algebra)

Spring 2019

Math 22 (Linear Algebra)

Fall 2018

Brigham Young University, Provo, UT (Instructor)

Math 112 (Calculus I)

Summer 2017

Brigham Young University, Provo, UT (Teacher's Assistant)

Math 112 (Calculus I)

Fall 2017

Math 113 (Calculus II)

Winter 2017

Brigham Young University, Provo, UT (Grader)

Math 570 (Matrix Analysis)

Winter 2017

Math 112 (Calculus I)

Fall 2015

Leadership and Community Service

Referee

<i>Journal of Number Theory</i>	2018 - Present
<i>Mathematische Zeitschrift</i>	2022 - Present
<i>Theory and Decision</i>	2024 - Present

Reviewer

<i>zbMATH Open</i>	2021 - Present
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K-12 Outreach

Utah Math Olympiad Committee Member	2015 - Present
Lumiere Mentor	2024 - Present
Activity Leader at Dartmouth Science Day (Games & Surreal Numbers)	April 8, 2023
Activity Leader at Lebanon Ward Pi Day (Trachtenberg Arithmetic & Random Walk)	March 25, 2023
Session Leader at Dartmouth Sonia Kovalevsky Day (Trachtenberg Arithmetic)	May 21, 2022
Activity Leader at Lebanon Ward Pi Day (Random Walk)	April 8, 2022
Exploring Mathematics Camp Leader (Graph Theory)	July 27-31, 2020
Exploring Mathematics Camp Leader (Cryptography)	July 13-17, 2020
Activity Leader at Lebanon Ward Pi Day (Random Walk)	March 7, 2020
Volunteer at Dartmouth Sonia Kovalevsky Day	May 11, 2019
Activity Leader at Dartmouth Science Day (Nim)	May 4, 2019
Math Circles Guest Speaker (Tropical Algebra)	February 24, 2018
Math Circles Guest Speaker (Continued Fractions)	October 21, 2017
Proofreader for Utah State Math Contest	February 2017
Math Circles Counselor	2013 - 2015

Dartmouth Graduate Student Council

Ad Hoc Healthcare Committee Founder and Co-Chair	2022 - 2023
◦ <i>Budget Committee Member</i>	Summer 2022
Finance Officer	2021 - 2022
◦ <i>Budget Committee Member</i>	Summer 2021
Representative for Math Department	2020 - 2021
◦ <i>Service Committee Member</i>	2020 - 2021
◦ <i>Budget Committee Member</i>	Summer 2020

Dartmouth Directed Reading Program

Mentor (Fuzzy Logic)	Winter 2023
Mentor (Decision Theory)	Spring 2022
Mentor (Fractional Calculus)	Winter 2022

Other

LMFDB Contributor	2019 - 2023
Dartmouth Algebra and Number Theory Seminar Organizer	2019 - 2022
BYU Putnam Team Captain	2014 - 2016

Thesis Defenses

Counting elliptic curves with a cyclic m-isogeny over \mathbb{Q} Dartmouth College PhD Thesis Defense	April 24, 2023
The arithmetic of modular grids BYU Master's Thesis Defense	June 22, 2018

Invited Talks

Counting elliptic curves with a cyclic m-isogeny Job Talk at Metron	February 9, 2023
Counting elliptic curves with a 7-isogeny BYU Colloquium	January 19, 2023
Counting elliptic curves with a 7-isogeny Simons Collaboration Annual Meeting	January 11, 2023
Counting 7-isogenies 2023 Joint Mathematics Meeting	January 6, 2023
A family of analogues to the Ramanujan-Robin Criterion BYU Number Theory Seminar	October 27, 2022

Other Conference Talks

Intersecting varieties with transcendental graphs Arizona Winter School 2023: Unlikely Intersections	March 8, 2023
The LCM product and Grönwall's theorem 2021 Maine-Québec Number Theory Conference (virtual)	October 3, 2021
Formal summation of divergent series 2020 Conférence de Théorie des Nombres Québec-Maine (virtual)	September 26, 2020
The arithmetic of modular grids 2019 Maine-Québec Number Theory Conference	October 5, 2019
The arithmetic of modular grids 33 rd Automorphic Forms Workshop	March 8, 2019
The arithmetic of modular grids Building Bridges: 4th EU/US Summer School + Workshop on Automorphic Forms	July 17, 2018
Zagier duality in level p modular spaces 32 nd Automorphic Forms Workshop	March 21, 2018
Zagier duality in level p modular spaces 2018 BYU Student Research Conference	March 3, 2018
Zagier duality in level p modular spaces Modular Forms are Everywhere Conference	May 24, 2017
Weakly holomorphic modular forms of level 11 31 st Automorphic Forms Workshop	March 7, 2017
Weakly holomorphic modular forms of level 11 2017 BYU Student Research Conference	March 4, 2017
Congruence relations in modular forms of prime levels greater than 7 2015 BYU Student Research Conference	March 21, 2015

Residues and independence numbers of graphs March 15, 2014
2014 BYU Student Research Conference

Other Seminar Talks

The Fox H -function March 28, 2023
Dartmouth Graduate Student Seminar

Geometric deep learning February 14, 2023
Dartmouth Graduate Student Seminar

Nearing nearings September 14, 2022
Dartmouth Graduate Student Seminar

Universal algebra and coalgebra March 30, 2022
Dartmouth Graduate Student Seminar

Cogalois theory February 16, 2022
Dartmouth Graduate Student Seminar

Cyclic resolution of singularities January 25, 2022
Reading Seminar on Hilbert Modular Surfaces

What if the Riemann hypothesis is false? January 19, 2022
Dartmouth Graduate Student Seminar

Inverse semigroups: groups without identity November 9, 2021
Dartmouth Graduate Student Seminar

Counting 7-isogenies November 8, 2021
Dartmouth Algebra and Number Theory Seminar

A sober look at pointless topology September 21, 2021
Dartmouth Graduate Student Seminar

Fast-growing series are transcendental April 21, 2021
Dartmouth Graduate Student Seminar (virtual)

Coalgebras and Hopf algebras April 15, 2021
Reading Seminar on Affine Group Schemes (virtual)

Absurd equalities and Runge's method: the degenerate case March 30, 2021
Dartmouth Algebra and Number Theory Seminar (virtual)

p -adic Hodge theory March 2, 2021
Reading Seminar on Classical and Quadratic Chabauty (virtual)

Odd, spoof quasiperfect factorizations February 9, 2021
Dartmouth Algebra and Number Theory Seminar (virtual)

A primer in social choice theory January 20, 2021
Dartmouth Graduate Student Seminar (virtual)

Examples of Kedlaya's algorithm November 19, 2020
Reading Seminar on Classical and Quadratic Chabauty (virtual)

The LCM product and Grönwall's theorem November 17, 2020
Dartmouth Algebra and Number Theory Seminar (virtual)

Reactive means and the prisoner's dilemma October 7, 2020
Dartmouth Graduate Student Seminar (virtual)

Formal summation of divergent series: an algebraic approach April 28, 2020
Dartmouth Algebra and Number Theory Seminar (virtual)

On the infinitude of the natural numbers Dartmouth Graduate Student Seminar	February 12, 2020
Variations of Hodge structures Reading Seminar on Shimura Varieties	November 26, 2019
Hodge structures Reading Seminar on Shimura Varieties	November 14, 2019
Savage's expected utility and making good decisions Dartmouth Graduate Student Seminar	November 13, 2019
Geometric and generalized calculus Dartmouth Graduate Student Seminar	October 8, 2019
Summing divergent series Dartmouth Graduate Student Seminar	July 31, 2019
Real analysis: a nonstandard approach Dartmouth Graduate Student Seminar	April 17, 2019
Why save the universe? Set theory with a universal set Dartmouth Graduate Student Seminar	January 16, 2019
The arithmetic of modular grids Dartmouth Graduate Student Seminar	September 26, 2018
Dioids and idempotent geometry II BYU Algebra Seminar	March 13, 2018
Dioids and idempotent geometry I BYU Algebra Seminar	February 27, 2018
Zagier duality in level p modular spaces BYU Number Theory Seminar	February 22, 2018
Average values of arithmetic functions BYU Number Theory Seminar	October 12, 2017
Weakly holomorphic modular forms of level 11 BYU Number Theory Seminar	February 9, 2017
Generating functions for canonical bases of certain level 11 weakly holomorphic modular forms BYU Number Theory Seminar	January 26, 2017
High rank elliptic curves with prescribed torsion BYU Number Theory Seminar	December 1, 2016
Heuristics for elliptic curves of high rank BYU Number Theory Seminar	October 20, 2016
A lemma regarding the Feit-Thompson conjecture BYU Number Theory Seminar	November 12, 2015
Algebraic number theory and the Feit-Thompson conjecture BYU Number Theory Seminar	October 1, 2015
Congruence relations in modular forms of prime levels greater than 7 BYU Number Theory Seminar	March 19, 2015
Hensel's lemma BYU Number Theory Seminar	February 12, 2015

Newton polynomials
BYU Number Theory Seminar

March 27, 2014

Other

Achievements and Honors

3rd Place in Virginia Tech Regional Math Competition October 2016
2nd Place in Search for High Rank Elliptic Curve
at 2016 Connecticut Summer School in Number Theory August 2016
Gold Palm Eagle Scout December 2012
Black Belt (Taekwondo) August 2012

Special Training

Dartmouth Mathematics Teaching Seminar Spring 2020
BYU Mathematics Teaching Seminar Fall 2018

Academic Interests

Analytic Number Theory • Arithmetic Geometry • Game Theory • Logic

Personal Interests

Reading • Writing • Philosophy • Hiking

Conferences and Workshops Attended

2024 *Simons Collaboration on Arithmetic Geometry, Number Theory, and Computation Annual Meeting* January 11-12, 2024
Virtual (Simons Foundation's Gerald D. Fischbach Auditorium, New York City)
Big Data Conference 2023 August 31 - September 1, 2022
Virtual (Harvard University, Cambridge)
Hilbert Modular Forms Infrastructure Week 4 May 8-12, 2023
Dartmouth College, Hanover
Arizona Winter School 2023: Unlikely Intersections March 4-8, 2023
University of Arizona, Tucson
2023 *Simons Collaboration on Arithmetic Geometry, Number Theory, and Computation Annual Meeting* January 11-12, 2023
Simons Foundation's Gerald D. Fischbach Auditorium, New York City
2023 *Joint Mathematics Meetings* January 4-7, 2023
Hynes Convention Center, Boston
Hilbert Modular Forms Infrastructure Week 3 December 12-16, 2022
Dartmouth College, Hanover
Modular Curves Workshop 2 November 5-9, 2022
MIT, Boston
Big Data Conference 2022 August 26, 2022
Virtual (Harvard University, Cambridge)
Explicit Methods for Modularity April 11-15, 2022
Virtual (Simons Collaboration)

<i>Arizona Winter School 2022: Automorphic Forms Beyond GL_2</i> Virtual (University of Arizona, Tucson)	March 5-9, 2022
<i>Hilbert Modular Forms Infrastructure Week 2</i> Dartmouth College, Hanover	February 21-25, 2022
<i>2021 Maine-Québec Number Theory Conference</i> Virtual (University of Maine, Orono)	October 2-3, 2021
<i>Spring 2021 Algebraic Geometry Northeastern Series</i> Virtual (Brown University, Providence)	May 4-5, 2021
<i>21st Algebra, Geometry and Combinatorics Day</i> Virtual (University of Notre Dame, Notre Dame)	April 10, 2021
<i>2021 Joint Mathematics Meetings</i> Virtual (American Math Society, Mathematical Association of America)	January 6-9, 2021
<i>Fall 2020 Algebraic Geometry Northeastern Series</i> Virtual (Stony Brook University, Stony Brook)	October 23-25, 2020
<i>2020 Conférence de Théorie des Nombres Québec-Maine</i> Virtual (Université Laval, Québec)	September 26-27, 2020
<i>14th Algorithmic Number Theory Symposium</i> Virtual (University of Auckland, Auckland)	June 29 - July 4, 2020
<i>UNCG Summer School in Computational Number Theory and Algebra: Ergodic Theory with Applications to Continued Fractions</i> Virtual (University of North Carolina, Greensboro)	May 18-22, 2020
<i>2019 Maine-Québec Number Theory Conference</i> University of Maine, Orono	October 5-6, 2019
<i>Fall 2019 Algebraic Geometry Northeastern Series</i> Boston College, Boston	September 20-22, 2019
<i>33rd Automorphic Forms Workshop</i> Duquesne University, Pittsburgh	March 6-10, 2019
<i>Building Bridges: 4th EU/US Summer School + Workshop on Automorphic Forms and Related Topics</i> Alfréd Rényi Institute of Mathematics, Budapest	July 9-20, 2018
<i>32nd Automorphic Forms Workshop</i> Tufts University, Medford	March 19-22, 2018
<i>Modular Forms are Everywhere</i> Max Planck Institute for Mathematics, Bonn	May 15-26, 2017
<i>31st Automorphic Forms Workshop</i> East Tennessee State University, Johnson City	March 6-9, 2017
<i>2017 BYU Student Research Conference</i> Brigham Young University, Provo	March 4, 2017
<i>2016 Connecticut Summer School in Number Theory</i> University of Connecticut, Storrs	August 8-14, 2016
<i>2015 BYU Student Research Conference</i> Brigham Young University, Provo	March 21, 2015

