

Andrew R. Tawfeek

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EDUCATION

- **University of Washington** Seattle, WA
Doctor of Philosophy in Mathematics *Sept. 2021 - June 2026 (Expected)*
 - **Advisors:** Sándor Kovács, Farbod Shokrieh
 - **Dissertation:** A Tropical Framework for using Porteous' Formula
- **Amherst College** Amherst, MA
Bachelor of Arts in Mathematics *Jan. 2018 - Jan. 2021*
 - **Advisor:** David A. Cox

PAPERS AND PREPRINTS

6. *Taming Wild Knots with Recursive Mosaics*, with Mary Deng, Allison K. Henrich, and Sean H. Kawano. In preparation.
5. *A Tropical Framework for using Porteous' Formula*. Submitted.
4. *Topological Signatures of ReLU Neural Network Activation Patterns*, with Vicente Bosca, Tatum Rask, Branden Stone, and Sunia Tanweer. Accepted to *Proceedings of Machine Learning Research* (2025).
3. *A^1 -Brouwer degrees in Macaulay2*, with Nikita Borisov, Thomas Brazelton, Frenly Espino, Thomas Hagedorn, Zhaobo Han, Jordy Lopez Garcia, Joel Louwsma, and Gabriel Ong. Published in *Journal of Software for Algebra and Geometry* (2024).
2. *On discrete gradient vector fields and Laplacians of simplicial complexes*, with Ivan Contreras. Published in *Annals of Combinatorics* (2023).
1. *Quantum Jacobi forms and sums of tails identities*, with Amanda Folsom, Lizzie Pratt, and Noah Solomon. Published in *Research in Number Theory* (2022).

HONORS AND AWARDS

- **Amherst Memorial Fellowship ($\times 3$)** Amherst College
Awarded three consecutive years (\$4,300, \$4,600, and \$7,700) for progress in Ph.D. *April 2021, 2022, & 2023*
- **Excellence in Teaching Award** University of Washington
Awarded in recognition of performance and commitment to teaching *December 2022*
- **Robert H. Breusch Prize in Mathematics** Amherst College
Awarded for, in the opinion of the faculty, presenting the best honors thesis in mathematics *May 2021*
- **Inducted Sigma Xi** Amherst College
National scientific research honor society *April 2021*
- **Provost Fellowship** University of Washington
Awarded an additional \$10,000 towards matriculation to Ph.D. program *February 2021*
- **Outstanding Poster Award ($\times 2$)** Joint Mathematics Meeting
Provided a "very clear, well-organized, and enthusiastic presentation on high-level work" *January 2020 & 2021*
- **Walker Award for Leadership** Amherst College
Outstanding leadership and contributions to the Mathematics and Statistics community *May 2020*

RECENT AND UPCOMING PRESENTATIONS

Taming Wild Knots with Recursive Mosaics

- AMS Special Session, Knots, Links, Geometry, and Related 3-Manifolds, JMM, January 2026
- Algebraic Structures in Knot Theory and 3-dimensional Topology, Spring Western AMS Sectional, Boise State University, March 2026

Topological Signatures of ReLU Neural Network Activation Patterns

- Topology, Algebra, and Geometry in Data Science, UC San Diego, December 2025

A Tropical Framework for Using Porteous' Formula

- Summer Research Institute in Algebraic Geometry, Colorado State University, July 2025
- Lloyd Roeling Conference in Algebraic Topology, University of Louisiana, Lafayette, March 2024
- Arithmetic, Birational Geometry, and Moduli Spaces, Brown University, June 2023
- Western Algebraic Geometry Symposium (WAGS), Washington University in St. Louis, November 2023

NOTABLE SOFTWARE PROJECTS

neural-network-elements

Interactive web-based tool for building, training, and analyzing multi-layer ReLU neural networks with real-time decision boundary visualization, polyhedral decomposition, and dual graph spectral analysis. Developed at GTRI.

discrete-gradients

Python implementation of discrete gradient vector fields and Laplacian eigenvalue computation on simplicial complexes, accompanying published research in *Annals of Combinatorics*.

knot_mosaics

Python library for knot mosaic enumeration and recursive construction of wild knots, including graph neural network models for automated knot invariant classification.

TEACHING

- **University of Washington** Seattle, WA
Instructor *Summer 2023*
 - **MATH 441: Topology:** Introduction to metric and topological spaces, convergence, continuity, products, connectedness, and compactness
- **University of Washington** Seattle, WA
Teaching Assistant *Sep. 2021 - Present*
 - **MATH 464/465: Numerical Analysis I & II:** Sp2024, Au2024, Wi2025, Au2025, Wi2026
 - **MATH 442/443: Differential Geometry of Curves and Surfaces:** Winter 2023, Spring 2023
 - **MATH 224: Advanced Multivariable Calculus:** Spring 2025
 - **MATH 208: Linear Algebra with Applications:** Summer 2022
 - **MATH 180/ART 255: Art and Mathematics as Embodied Practices:** Autumn 2022
 - **MATH 125: Calculus with Analytic Geometry II:** Au2021, Wi2022, Sp2022, Au2023, Wi2023, Wi2024
- **University of Washington** Seattle, WA
Washington Directed Reading Program (WDRP) *Jan. 2022 - Present*
 - **Role:** Mentored undergraduate students on quarter-long independent studies on advanced topics
 - **Topics:** Discrete Morse Theory (Wi2022), Persistent Homology (Wi2022), Chip Firing on Graphs (Sp2022), Nonlinear Algebra (Au2022), Singularities (Sp2024), Knot Theory (Au2024), Ideals, Varieties, and Algorithms (Wi2025)
- **University of Washington** Seattle, WA
Washington eXperimental Mathematics Lab (WXML) *Sep. 2022 - Present*

- **Permutation Polynomials:** Studied bijective polynomial automorphisms of finite fields and their correspondence with elements of the symmetric group (Au2023, Wi2023)
- **Gerrymandering:** Developed fair redistricted maps of Washington state via Markov chains, Monte Carlo methods, and generative AI (Sp2024)
- **Teaching a Computer to Knot:** Built and trained a graph neural network to classify knots and knot invariants using matrix-structured mosaics (Au2025)
- **Wild Knot Mosaics:** Developed an expanded theory of mosaics to represent wild knots exhibiting infinite-complexity along their strands (Wi2025–2026)

Amherst College

Amherst, MA

Course Grader

Aug. 2020 - May 2021

- **Fall 2020:** MATH 460: Analytic Number Theory, MATH 255: Geometry
- **Spring 2021:** MATH 420: Arithmetic of Elliptic Curves, MATH 310: Theory of Partitions

Bristol Community College

Fall River, MA

Supplemental Instructor

Jan. 2017 - May 2017

- **Multivariate Calculus:** Met students three times per week (twice in person, once online) to review material and reinforce concepts

Bristol Community College

Attleboro, MA

Subject Tutor

Sept. 2016 - Dec. 2017

- **Subjects:** Statistics, algebra, precalculus, calculus, differential equations, classical mechanics, electromagnetism, and general chemistry; met with 10–15 students weekly

INDUSTRY EXPERIENCE

● Georgia Tech Research Institute

Atlanta, GA

Research Scientist

May 2025 - Present

- **Geometric Trust for AI:**
 - Applied persistent homology methods to ReLU neural networks via their binary state polyhedral decomposition
 - Developed filtration algorithms tracking topological changes throughout neural network training epochs
 - Applied weighted graph Laplacians for binary classification using Fiedler vector partitioning methods
- **Pathogen Risk Optimization Through Evaluation and Computational Trust (PROTECT):**
 - Ongoing effort to integrate cybersecurity strategies into prevention of pathogen colonization and infection
 - Developed predictive ML models for multi-class classification in high-dimensional feature spaces
 - A particular focus is placed on ESKAPE pathogens, the notorious hard-to-treat and antibiotic resistant bacteria

● Erdős Institute

Remote

Quantitative Finance Boot Camp

Spring 2026

- **Topics:** Options pricing (Black-Scholes, Greeks), Monte Carlo, delta hedging, volatility modeling in Python

SERVICE

● Reviewer for zbMATH Open

FIZ Karlsruhe

Providing reviews of published articles and books in various fields of mathematics

Nov. 2024 - Present

● Delegate for Mathematical Sciences on Capitol Hill (#MathSciOnTheHill)

Washington, D.C.

One of 280 mathematicians; advocated for research funding in U.S. House and Senate meetings

Jan. 2026

● Organizer of 5+ Graduate Reading Seminars

University of Washington

Topics: algebraic geometry, tropical geometry, knot theory, ∞ -categories, arithmetic topology

2022 - 2025

● Joint Mathematics Meeting Fundraising (\$10,850 for 14 students)

Amherst College

Acquired funding after budgetary work in-discussion with administration and college president's office

2019 & 2020