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

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 simulation, delta hedging, volatility modeling, stochastic processes (GBM), jump-diffusion models (Merton), permutation tests — implemented in Python
  - **Final Project — *Market Volatility Complex***: Python library applying TDA to finance — built simplicial complexes from rolling volatility correlations, used HMM regime detection on topological features for signal generation with walk-forward backtesting

Technical Skills

Programming: Python, Java, C++, SQL, MATLAB, Git, Docker, Linux/Unix
ML/Statistics: PyTorch, TensorFlow, scikit-learn, pandas, time series analysis, Monte Carlo, stochastic processes
Finance: Options pricing & Greeks, jump-diffusion models, delta hedging, regime detection (HMM), risk modeling

Notable Software Projects

tropicalmoduli
Computational tools in Python and SageMath for generating and analyzing cells of tropical moduli spaces, supporting dissertation research in tropical algebraic geometry.

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.

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. $\mathbb{A}^1$*-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** (×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** (×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, AMS Sectional Meeting, 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, Novemeber 2023

On discrete gradient vector fields and Laplacians of simplicial complexes
· AMS Special Session on Graphs and Matrices, University of Utah, October 2022
· AMS Special Session on Combinatorial Approaches to Topological Structures, JMM, April 2022
· Combinatorics and Geometry Seminar, University of Washington, June 2021
· Graduate Student Combinatorics Conference (GSCC), University of Minnesota, April 2021
· Spring Eastern AMS Meeting, Brown University, March 2021

Teaching

- **University of Washington** — Seattle, WA
  Instructor — *June 2023 - Aug. 2023*
  - **MATH 441: Topology**:
    introduction to metric and topological spaces, convergence, continuity, products, connectedness, and compactness
    · Summer 2023 (15 students)

- **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*
  - **Description**: Mentored undergraduate students on a quarter-long independent study on advanced topics.
  - **Topics**: Discrete Morse Theory (Winter 2022), Persistent Homology (Winter 2022), Chip Firing on Graphs (Spring 2022), Nonlinear Algebra (Autumn 2022), Singularities (Spring 2024), Knot Theory (Autumn 2024), Ideals, Varieties, and Algorithms (Winter 2025)

- **University of Washington** — Seattle, WA
  Washington eXperimental Mathematics Lab (WXML) — *Sep. 2022 - Present*
  - **Description**: Mentored a group of 3 - 5 undergraduate students in conducting mathematics research.
    - **Permutation Polynomials (Autumn 2023, Winter 2023):** Studied bijective polynomials automorphisms of finite fields and researched their correspondence with elements of the symmetric group.
    - **Mathematics of Gerrymandering (Spring 2024):** Developed various fair redistricted maps of the state of Washington by means of Markov chains, Monte Carlo methods, and generative AI.
    - **Wild Knot Mosaics (Winter 2025, Spring 2025, Autumn 2025):** Developed an expanded theory of mosaics to represent wild knots, which are knots that exhibit infinite-complexity along their strands.
    - **Teaching a Computer to Knot (Autumn 2025):** Utilizing the matrix-structure of mosaics for encoding knots, we build and train an AI model, namely a graph neural network, to classify knots and knot invariants.

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*
- **Description**:
  · Met students of a multivariate calculus course three times per week (twice in person and once online)
  · Ensured they were properly grasping concepts by reviewing class material

Bristol Community College Attleboro, MA

Subject Tutor *Sept. 2016 - Dec. 2017*

- **Description**:
  · Students would reserve hour slots to meet individually, met with 10 - 15 students weekly
  · Tutored in fundamental and business statistics, elementary algebra, precalculus, the calculus sequence, discrete mathematics, differential equations, classical mechanics, electromagnetism, and general chemistry

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*