Joshua Turner, PhD

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Research Summary

1. **The Hatcher-Quinn Invariant and Differential forms**

   The Hatcher-Quinn invariant is a bordism class which detects the obstruction to isotopically removing intersections in a certain "metastable range." The research from my dissertation employs a diffeology approach to modeling the cohomology of the generalized path space with a bar construction along with explicitly constructing an analytical representation of the intersection class. This research connects higher order intersection invariants and string topology. In my current project, I am working to construct a measure on the space of differential forms on a smooth, compact Riemannian manifold and relate this measure to the Hatcher-Quinn Invariant.

2. **Data Science and Computational Topology**

   In my first machine learning paper, I combined topological methods with machine learning to develop models which capture the underlying physics of the relationship between streamflow, surrounding geographic features. In my latest research, I am working with a student to use the mapper algorithm and zig-zag persistent homology to model the spatial and temporal properties of drug overdose cases in the state of Virginia.

Education

2015–2021 **Ph.D. in Mathematics**, *Department of Mathematics, Wayne State University*, Detroit, MI, USA

Advisors: John R. Klein and Vladimir Chernyak.

PhD Thesis *The Hatcher-Quinn Invariant and Differential forms*

2013–2015 **M.S. in Mathematics**, *Department of Mathematics, Ball State University*, Muncie, Indiana

Master's Thesis *An Analysis of the Henstock-Kurzweil Integral*

Advisor: Ahmed Mohammed.

2005–2013 **B.A. in Mathematics**, *Department of Mathematics, Indiana University (Kokomo)*, Kokomo, Indiana

Awards & Honors

2012 Mathematics Student of the Year, Indiana University (Kokomo).

2013 Mathematics Student of the Year, Indiana University (Kokomo).

2019 Maurice J. Zelonka Endowed Scholarship (Wayne State University).

Teaching Experience

2024–Present **Assistant Professor, University of Virginia**

Courses taught: Applied Linear Algebra (MATH3350), Introduction to Probability (MATH3100), A Survey of Calculus I (MATH1210), Transition to Higher Mathematics (MATH3000), Elementary Numerical Analysis (MATH4300), Independent Study (MATH4993).

Responsibilities include course coordination, mentoring learning assistants, curriculum development, and implementation of active learning strategies.

2020–2023 **Online Instructor, Ho Chi Minh City University**

Courses taught: Numerical Methods.

Developed and delivered fully online courses to international students, integrating remote teaching best practices, digital assessment strategies, and culturally responsive pedagogy.

2025 **Course Development and Independent Instruction**

Developed and taught the undergraduate course "Differential Geometry and the Shape of Data" (Math Experimental Lab), emphasizing discrete differential geometry and computational methods.

Supervised an independent study preparing a student for national mathematics competitions, focusing on advanced problem-solving and proof strategies.

2014–2020 **Other Courses Taught**

Courses taught at Wayne State University, Ball State University, and other institutions include:

MAT125 - Mathematics in the Real World, MAT1000 - Mathematics in Today's World, MAT1800 - Elementary Functions, MAT2010 - Calculus I, MAT2020 - Calculus II, MAT2030 - Calculus III, MAT2150 - Differential Equations, MAT1050 - Intermediate Algebra with Trigonometry, MT1009 - Numerical Methods, CMP1438-1440 - TensorFlow Beginner to Advanced.

Instructional Training

2024 2025 **University of Virginia Teaching Workshop:** A week-long workshop at the University of Virginia focusing on teaching and effective use of, peer-reviewed, state of the art techniques. A particular emphasis is placed on the student experience and how we as educators can improve that experience.

2015 **Teaching Mathematics in College:** A semester-long course focusing on presentation, test-writing, grading, classroom management, and use of technology at Wayne State University.

2013 - 2015 Teaching Workshop, Ball State University: Weekly teaching meetings to discuss teaching strategies and student service.

Industry Experience

2023 - 2024 **Data Scientist, Westat**

Worked with large language models to create a machine learning model which could classify various grants by type for the National Institute of Health. Additionally, I created deployment pipelines that allowed continuous integration and continuous testing of various types of statistical and machine learning models.

2022 - 2023 **Data Scientist, Pringle Robotics**

Conducted a mathematical study of restaurant sales patterns using autoregressive time series models and formulated an optimization framework minimizing delivery time and distance for robotic couriers. Additionally, I created deployment pipelines that allowed continuous integration and continuous testing of the optimized courier algorithms.

2021 - 2022 **Data Scientist, Hottinger Bruel & Kjaer**

Conducted a machine learning–based calibration study for the US Army Corps of Engineers' RAPID hydrological model, demonstrating that data-driven regression and copula methods can effectively estimate streamflow parameters in ungauged rivers, reducing calibration time and improving predictive performance.

Conferences

2025 Midwest Topology Conference, Indiana University, Purdue University, Indianapolis.

2025 Riverside Workshop on Geometric Group Theory, University of Virginia.

2025 Mid Atlantic Topology Conference, University of Virginia.

2019 Midwest Topology Conference, Michigan State University.

2019 Geometry and Topology Conference, University of Illinois, Urbana - Champaigne.

2018 Midwest Topology Conference, Indiana University.

2017 Midwest Topology Seminar, Wayne State University.

2017 Midwest Topology Seminar, The University of Notre Dame.

2017 The 15th annual Graduate Student Topology and Geometry Conference, Michigan State University.

Service

2026 **MATH 1210 Coordinator**

Currently serve as coordinator for a multi-section Survey of Calculus I course consisting of eleven sections. Lead the development and implementation of a unified course structure, including construction of the common syllabus, coordinated weekly schedule, shared assessments, and common examinations. Supervise and mentor seven instructors, eleven learning assistants, and academic peer coaches who provide structured tutoring support. Direct weekly instructional team meetings focused on course alignment, student learning outcomes, and evidence-based pedagogy. Oversee the pedagogical development of graduate teaching assistants through structured mentoring, classroom observations, and ongoing feedback to promote effective, student-centered instruction.

2025 **University of Virginia Driving Change Initiative**

In this task, designing, developing and coding web-pages for the mathematics department at the University of Virginia. This is an attempt to give students a more intuitive and user friendly interface when trying to decide which courses are most important for their majors. The web-pages will offer a sequence of interactive diagrams and drop-down menus that students can use to focus on a particular path for their desired mathematical concentration

2025 **MATH 1210 Co-coordinator**

I help co-coordinate the “Survey of Calculus I" course at the university of Virginia. My duties include managing 15 learning assistants; this includes weekly meetings, approving time and pairing them with various instructors as graders for large coordinated exams. Additionally, I help with the overall schedule and structure of the course in an attempt to improve both the instructor and student experience.

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2012-2013 **Habitat for Humanity, Kokomo, IN**

Each weekend for one year I helped disenfranchised families in Indiana by building homes. My duties included all manners of construction including carpentry, masonry, electrical work and plumbing.

2012 - 2013 **Co-organizer, Math Club, Indiana University**

I helped schedule a game night each week for mathematics students to unwind and discuss various types of gaming strategy.

2011-2012 **Samaritan Caregivers, Kokomo, IN**

Every morning for one year I would record myself reading the newspaper aloud for the visually impaired.

Talks

2025 **Lectures on Symplectic Geometry, Josh Turner**, Graduate Reading Course, University of Virginia.

2019 **The Hatcher-Quinn Invariant and Differential Forms, Josh Turner**, Graduate Seminar, Wayne State University.

2019 **An Intersection Invariant for the Path Space of a Manifold, Josh Turner**, Graduate Seminar, Wayne State University.

2019 **Thom Complexes, Michael Atiyah**, Graduate Seminar, Wayne State University.

2019 **On The Cobar Construction, J.F. Adams**, Graduate Seminar, Wayne State University.

2019 **Bordism and Cobordism, Michael Atiyah**, Graduate Seminar, Wayne State University.

2019 **Calculation of K-Theory for C^*- Algebras**, Graduate Course, Wayne State University.

2018 **An Introduction to Cobordism, Tom Weston**, Graduate Seminar, Wayne State University.

2018 **An Introduction to K-Theory**, Graduate Seminar, Wayne State University.

Volunteering & Community Outreach

Fall 2025 **Math Experimental Lab: Differential Geometry and the Shape of Data**

Developed and taught an undergraduate course in discrete differential geometry emphasizing the translation of smooth differential geometry concepts—curvature, geodesics, and differential forms—into discrete computational frameworks. Students designed and implemented algorithms in Python and C++ to analyze and classify 3D data sets based on local curvature, bridging theoretical geometry with computational methods and data-driven analysis.

Fall 2025 **Independent Study: Techniques for Proofs and Problem Solving in Mathematics**

Supervised an undergraduate independent study preparing a student for national mathematics competitions, focusing on advanced problem-solving techniques and proof strategies, including induction, invariants, symmetry, and the Extreme Principle. Conducted biweekly meetings to work through problems of varying difficulty, developing both mathematical reasoning and creative problem-solving skills.

Fall 2025 **Community Outreach in Mathematics Courses**

Integrated community engagement into the "Transition to Higher Mathematics" course by designing assignments in which students visited a local Charlottesville, VA high school to present mathematical concepts, fostering both communication skills and outreach experience.

Technical Skills

— Computer Programming: Python, C++, Mathematica and R.

— Productivity Applications: LaTeX, SQL,and Excel.

Publications

— Zhao, Ying, Chadha, Mayank, Olsen, Nicholas, Yeates, Elissa, Turner, Josh, Gugaratshan, Guga, Qian, Guofeng, Todd, Michael D., Hu, Zhen *Machine Learning-Enabled RAPID Calibration of Hydrological Model Parameters*(Journal of Hydroinformatics Vol 00 No 0, 1 doi: 10.2166/hydro.2023.030)

— Turner, Joshua,*The Hatcher-Quinn Invariant and Differential Forms.* PhD Thesis, Wayne State University 2021

— Chernyak, Vladimir, Klein John R., Turner, Joshua,*The Hatcher-Quinn Invariant and Differential Forms.* (In Preparation) 2025

— Grigorian, Mariam, Turner, Joshua *A Topological Analysis of the Spread of Drug Overdose Across the State of Virginia.* (In Preparation) 2025