

# Kyle Miller

4167 McHenry Library  
Santa Cruz, CA 95064  
✉ kymiller@ucsc.edu  
🌐 kmill.github.io

## Academic Appointments

- 2021–present **Postdoc**, *University of California*, Santa Cruz, CA  
2022–2023 **Postdoc**, *Université Paris-Saclay (FMJH)*, Orsay, France

## Research Interests

I am interested in finding ways that computers can be used in mathematics, education, and engineering. I work on formalization with interactive theorem provers, and I am exploring applications of this technology beyond formal verification.

My mathematics research centers around low-dimensional topology, knot theory, and singularity theory.

## Education

- 2014–2022 **Ph.D.**, *University of California*, Berkeley, CA  
Advisor: Ian Agol.  
Thesis: *Singularity theory for extended cobordism categories and an application to graph theory*.  
2008–2012 **S.B.**, *Massachusetts Institute of Technology*, Cambridge, MA  
Major: Mathematics with Computer Science. Minor: Music.

## Professional Experience

- 2023– **Research Software Engineer**, *Lean Focused Research Organization (FRO)*  
I look for, specify, and implement improvements to the experience of using Lean, the functional programming language and interactive theorem prover.  
Su2015 **Software Engineer**, *Swift Navigation, Inc.*, San Francisco, CA  
Designed and implemented *Plover*, an experimental programming language for linear algebra in embedded applications, with Scott Kovach.  
2013–2014 **Research Assistant**, *Microsoft Research New England*, Cambridge, MA  
Empirical microeconomics research with Markus Mobius and Susan Athey regarding news bias in social media. Designed analyses to run efficiently on hundreds of terabytes of data.  
2012–2013 **Software Engineer**, *Vecna Technologies, Inc.*, Cambridge, MA  
Enterprise Java software for online healthcare systems.

## Publications and Preprints

### In preparation

- Kolichala, Kovach, Miller, and Kjolstad, *Indexed stream fusion: a compiler framework for optimizing traversals over general container types*  
Miller and Massot, *Informalization: natural structured proofs from formalized mathematics*  
Miller, *The two-variable virtual Yamada polynomial*.  
Miller, *Surface graph invariants as extended 2D TQFTs*.

### Published

- 2023 Miller, *The homological arrow polynomial for virtual links*, *Journal of Knot Theory and Its Ramifications* (2023), doi:10.1142/S0218216523500050.

- 2021 Anderson, Baker, Gao, Kegel, Le, Miller, Onaran, Sangston, Tripp, Wood, and Wright, *L-space knots with tunnel number  $> 1$  by experiment*, Experimental Mathematics (2021), doi:10.1080/10586458.2021.1980753.
- 2018 McPhail-Snyder and Miller, *Planar diagrams for local invariants of graphs in surfaces*, Journal of Knot Theory and Its Ramifications (2020), doi:10.1142/S0218216519500937.
- [Preprints](#)
- 2020 Gusakov, Mehta and Miller, *Formalizing Hall's Marriage Theorem in Lean*. arXiv:2101.00127.
- 2020 *All the ways I know how to define the Alexander Polynomial* (link to pdf)

## Open-source Artifacts

- 2019–present **KnotFolio**, an online program for recognizing and identifying drawings of knots and links. <https://knotfol.io/>
- 2021–present **Mathlib**, the Lean mathematics library, maintainer and contributor: <https://leanprover-community.github.io/teams/maintainers.html>
- 2021–present **Pyquiz**, a tool for constructing Canvas quizzes with randomization and custom explanations. <https://github.com/UCBMath/pyquiz>
- 2018–present **Planalg**, a Mathematica library for computations with planar algebras and diagrammatic categories. <https://github.com/kmill/planalg>
- 2015 **Plover**, high-level programming language for linear algebra on embedded systems. <https://github.com/swift-nav/plover>

## Talks

### Invited

- Jan 2024 Special Session on Algebraic Structures in Knot Theory. *The homological arrow polynomial for virtual links*.
- Sep 2023 Workshop on Libraries of Formal Proofs and Natural Mathematical Language, EuroProofNet. *Informalizing formalized mathematics using the Lean theorem prover*.
- Apr 2023 University of Fribourg algebra seminar. *Informalizing formalized mathematics using the Lean theorem prover*.
- Apr 2023 Languages, Systems, and Data Seminar. *Informalizing formalized mathematics using the Lean theorem prover*.
- Nov 2022 Université Paris-Saclay seminar on computer formalization of mathematics. *Some thoughts on formalizing basic knot theory*.
- Nov 2021 UC Santa Cruz geometry and analysis seminar. *The homological arrow polynomial*.
- Nov 2021 Oklahoma State University topology seminar. *The homological arrow polynomial*.
- Jan 2021 Special Session on Developments in Spatial Graphs, JMM. *A 2D TQFT approach to topological graph polynomials and graphs in thickened surfaces*.
- Dec 2019 University of Virginia geometry seminar. *A TQFT approach to topological graph polynomials*.
- Nov 2019 Rice topology seminar. *Invariants of graphs in thickened surfaces from topological graph polynomials*.
- Nov 2019 Special Session on Invariants of Knots and Spatial Graphs, Fall Western Sectional Meeting of the AMS. *Invariants of virtual spatial graphs based on topological graph polynomials*.

### Expository

- Su2020 UC Berkeley Lean seminar. 3 talks about math in the Lean proof assistant.

- Fa2019 Student 3-manifold seminar, UCB. 6 talks on topics in 3-manifold topology.
- Sp2019 Student 3-manifold seminar, UCB. 8+ talks on combinatorial 3-manifold topology.
- Feb 2019 3-manifold seminar, UCB. *The arithmeticity of figure eight knot orbifolds.*
- Nov 2018 3-manifold seminar, UCB. *What is an alternating knot?*
- Sep 2018 GRASP, UCB. *The Jones polynomial and the Temperley–Lieb category.*
- Nov 2017 Knot theory topics course, UCB. *Quandles.*
- Sep 2017 3-manifold seminar, UCB. *Spatial graph invariants.*
- Apr 2017 Knot Another Seminar, UCB. *The Alexander ideal.*

## Service

- 2021–present Maintainer for `mathlib`, the Lean mathematics library.
- Sep. 2023 Co-instructor for *Formal Mathematics and Computer-Assisted Proving* workshop at Hausdorff Center for Mathematics, University of Bonn
- June 2023 Co-instructor and invited speaker for *Formalization of Mathematics* workshop at SLMath (formerly MSRI) in Berkeley, CA
- 2020 Reviewed for Annales de l’Institut Henri Poincaré D: Combinatorics, Physics and their Interactions.
- Fa2019 **Student 3-Manifold Seminar (organizer)**, *University of California*, Berkeley, CA
- Sp2019 **Student 3-Manifold Seminar (organizer)**, *University of California*, Berkeley, CA
- 2015–2019 **Directed Reading Program (mentor)**, *University of California*, Berkeley, CA  
Fall 2015, Spring 2017, Fall 2017, Fall 2018, Fall 2019.

## Teaching Experience

### University of California, Santa Cruz

- Wi2024 Math 11B Calculus with Applications (172 students)
- Sp2022 Math 116 Combinatorics
- Wi2022 Math 110 Number Theory

### University of California, Berkeley

- Fa2020 Discussion sections, Math 54 Linear Algebra
- Sp2020 Discussion sections, Math 1B Calculus
- Sp2017 Discussion sections, Math 55 Discrete Mathematics
- Fa2016 Discussion sections, Math 54 Linear Algebra
- Su2016 Lecture and discussion sections, Math 54 Linear Algebra
- Sp2016 Discussion sections, Math 54 Linear Algebra
- Fa2015 Discussion sections, Math 1B Calculus
- Sp2015 Discussion sections, Math 1A Calculus
- Fa2014 Discussion sections, Math 1A Calculus

## Additional research experience

- 2009–2010 **UROP**, *MIT Computer Science and AI Laboratory (CSAIL)*, Cambridge, MA  
Worked on natural human-computer interactions for mathematics, and worked on expert systems for designing vehicles for a DARPA project. With Randall Davis.

Sp2009 **UROP**, *MIT Humans and Automation Laboratory*, Cambridge, MA  
Developed a software platform for measuring the effects of team structures on situational awareness.

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## Awards

- 2018–2019 Awarded support by the UCB NSF Research Training Group in Geometry and Topology for Spring 2018, Spring 2019, Summer 2019, and Fall 2019.
- 2009 MIT Licklider UROP prize for the best undergraduate research project in the area of human-computer interaction.

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## Personal

- 2011 MIT Philip Loew Memorial Award for creative accomplishment in music.