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

Kyle Miller

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

Published

2023 *The homological arrow polynomial for virtual links*, Journal of Knot Theory and Its Ramifications (2023), arXiv:2207.02427.

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), arXiv:1909.00790.

2018 McPhail-Snyder and Miller, *Planar diagrams for local invariants of graphs in surfaces*, Journal of Knot Theory and Its Ramifications (2020), arXiv:1805.00575.

Preprints

2020 *All the ways I know how to define the Alexander Polynomial* (link to pdf)

Unpublished

2020 Gusakov, Mehta and Miller, *Formalizing Hall's Marriage Theorem in Lean.* arXiv:2101.00127.

In preparation

Indexed stream fusion, with Scott Kovach and Fredrik Kjolstad

Doing graph theory in Lean

The two-variable virtual Yamada polynomial.

Surface graph invariants as extended 2D TQFTs.

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 Frieburg 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

Sep. 2023 Teaching assistant for *Formal Mathematics and Computer-Assisted Proving* at Hausdorff School, University of Bonn

June 2023 Speaker and teaching assistant for *Formalization of Mathematics* summer school at SLMath (formerly MSRI) in Berkeley, CA

2021–present Maintainer and contributor for `mathlib`, the Lean mathematics library.

2021–present Maintainer for `pyquiz`, a tool for constructing Canvas math quizzes with randomness.

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

Su2019 **KnotFolio**, an online program for recognizing and identifying drawings of knots and links. https://knotfol.io/

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.

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.

Personal

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