

Emily Riehl

What counts as “good math research” in an age of AI?

The old way of doing math research



Advances in Mathematics 495 (2026) 110965



The equivariant model structure on cartesian cubical sets



Steve Awodey^{a,*}, [Evan Cavallo](#)^b, [Thierry Coquand](#)^b,
Emily Riehl^c, [Christian Sattler](#)^d



Main theorem proven in 2019

Preprint posted in 2024

Published in 2026:

113 pages

plus a computer formalization in Agda

Project started in 2017

Preliminary results reported in 2018

Resumed work in 2023

Preprint posted in 2026

Submitted for publication: 64 pages

The new way of doing math research



hexagon:2610.00138v1

MATH.AT — ALGEBRAIC TOPOLOGY

Weak chromatic splitting fails at $n = p$ for every odd prime p

Contributed by Agnes Beaudry, Tomer Schlank

We prove that for every odd prime p there is a height n for which the map $L_{\{n-1\}S_p} \rightarrow L_{\{n-1\}L_{\{K(n)\}S_p}$ is not injective on homotopy groups, hence not the inclusion of a wedge summand. In particular, for such pairs...

PRIMARYLY HUMAN-WRITTEN TEXT

HUMAN UNDERSTANDING: ALL PARTS

Oct 07, 2026

PDF ↗

View work →

Acknowledgments. The disproof of the weak chromatic splitting conjecture given in this note was produced autonomously by Claude. We did not contribute any ideas and Claude was not prompted on this problem but on Freyd's generating hypothesis in stable homotopy theory. Although the relationship between Freyd's generating hypothesis and the chromatic splitting conjecture is well established, for example, in work of Hopkins–Devnatz [Dev90, Dev98] (see also [Ho07, Bar20]), we did not expect Claude to find a counter example to the weak chromatic splitting conjecture, which we both believed to be true. We note recent progress on Freyd's generating hypothesis recently appeared in Ma–Xu [MX26].

The result arose in the context of paid consulting with Anthropic. Claude was run internally by Anthropic, using its own computing resources. The transcript was shared with us September 8, 2026. The mathematical exposition was drafted by us, Agnès Beaudry and Tomer Schlank, after we verified the details of Claude's disproof, on September 12, 2026. The result was announced at 2026 Clay Research Workshop on Telescopic Homotopy Theory and Algebraic K-theory, on September 21, 2026. This text is not AI generated. It was produced by us, using Claude only for copyediting.



What counts as “good math research” in an age of AI?



What counts as “**bad** math research” in an age of AI?

Aside: a new paradigm for mathematical proof



▼ IrrationalDemo.lean ●

FYS270LeanProject > ▼ IrrationalDemo.lean > { } Real > sqrt_two_irrational

```
import Mathlib.Analysis.Real.Sqrt
import Mathlib.Data.Nat.Prime.Defs
import Mathlib.Data.Rat.Sqrt

/-- A proof of the (ir)rationality of the square root of 2. -/

open Nat
You, 5 hours ago | author (You)
namespace Real

/-- The square root of 2 is irrational. That is, there do not exist
natural numbers `m` and `n`, with `gcd m n = 1`, so that
`sqrt 2 = m / n`. -/
theorem sqrt_two_irrational :
  ¬ (∃ (m n : ℕ), gcd m n = 1 ∧ sqrt 2 = m / n) := by
```

Lean InfoView ×

▼ IrrationalDemo.lean:16:2

▼ Tactic state

1 goal

$\vdash \neg \exists m\ n, m.\text{gcd } n = 1 \wedge \sqrt{2} = m / n$

▼ Messages (1)

▼ IrrationalDemo.lean:13:0

Goals accomplished!

► All Messages

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Lean InfoView ×

▼ IrrationalDemo.lean:16:2

▼ Tactic state

1 goal

| ⊢ ¬∃ m n, m.gcd n = 1 ∧ √2 = m / n

▼ Messages (0 1)

▼ IrrationalDemo.lean:13:0

Goals accomplished!

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theorem sqrt_two_irrational :
  ¬ (∃ (m n : ℕ), gcd m n = 1 ∧ sqrt 2 = m / n ) := by
  -- This is a proof of negation, so we assume that `∃ m n : ℕ`
  -- so that `gcd m n = 1` and `sqrt 2 * n = m`.
  intro {m, n, hyp, eq}
```

Lean InfoView ×

▼ IrrationalDemo.lean:17:23

▼ Tactic state

1 goal

m n : ℕ

hyp : m.gcd n = 1

eq : √2 = m / n

| ⊢ False

▼ Messages (0 1)

Aside: a new paradigm for mathematical proof



▼ IrrationalDemo.lean ●

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  ¬ (∃ (m n : ℕ), gcd m n = 1 ∧ sqrt 2 = m / n) := by
  -- This is a proof of negation, so we assume that `∃ m n : ℕ`
  -- so that `gcd m n = 1` and `sqrt 2 * n = m`.
  intro (m, n, hyp, eq)
  -- Using `eq : sqrt 2 = m / n` we prove that `2 * n ^ 2 = m ^ 2`.
  have eq2 : 2 * n ^ 2 = m ^ 2 := by
    have eq' := congrArg (fun x => x * x) eq
    simp only [ofNat_nonneg, mul_self_sqrt] at eq'
    apply cast_injective (R := ℝ)
    simp only [cast_mul, cast_ofNat]
    rw [eq']
    grind
  -- Using `eq2 : 2 * n ^ 2 = m ^ 2` and the fact that `2` is prime,
  -- we show `2 | m`.
  have lem1 : 2 | m :=
    Prime.dvd_of_dvd_pow (prime_iff.mp (prime_two)) ((n ^ 2, eq2.symm))
```

Lean InfoView ×

▼ IrrationalDemo.lean:30:2

▼ Tactic state

1 goal

m n : ℕ

hyp : m.gcd n = 1

eq : $\sqrt{2} = \frac{m}{n}$

eq2 : $2 * n^2 = m^2$

lem1 : $2 \mid m$

False

▼ Messages (1)

▼ IrrationalDemo.lean:13:0

Goals accomplished!

► All Messages

Aside: a new paradigm for mathematical proof



▼ IrrationalDemo.lean ●

FYS270LeanProject > ▼ IrrationalDemo.lean > {} Real > sqrt_two_irrational

```
have lem1 : 2 | m :=
  Prime.dvd_of_dvd_pow (prime_iff.mp (prime_two)) ((n ^ 2, eq2.symm))
-- Unpacking the definition of the type `2 | m`, `lem1` actually
-- proves `∃ k : ℕ, m = 2 * k`.
have (k, eq3) : ∃ k : ℕ, m = 2 * k := lem1
-- Substituting `eq3` into `eq2` proves `eq4 : 2 * n ^ 2 = (2 * k) ^ 2`.
have eq4 : 2 * n ^ 2 = (2 * k) ^ 2 := by
  rw [eq2, eq3]
-- By basic algebra, `eq4` simplifies to `eq5`.
have eq5 : n ^ 2 = 2 * k ^ 2 := by grind
-- Using `eq5 : n ^ 2 = 2 * k ^ 2` and the fact that `2` is prime,
-- we show `2 | n`.
have lem3 : 2 | n :=
  Prime.dvd_of_dvd_pow (prime_iff.mp (prime_two)) ((k ^ 2, eq5))
-- Since `2 | m` and `2 | n`, it follows that `2 | gcd m n`.
have lem4 : 2 | gcd m n :=
  Nat.dvd_gcd lem1 lem3
-- Since `2 | gcd m n` we have `gcd m n ≠ 1`.
have lem5 : gcd m n ≠ 1 :=
  Nat.not_coprime_of_dvd_of_dvd Nat.one_lt_two lem1 lem3
-- We now have `hyp : gcd m n = 1` and `lem5 : gcd m n ≠ 1`.
-- This is our contradiction!
-- Now `absurd hyp lem5` can be used to give an element of any type.
exact absurd hyp lem5
```

Lean InfoView ×

▼ IrrationalDemo.lean:51:2

▼ Tactic state

1 goal

```
m n : ℕ
hyp : m.gcd n = 1
eq  : √2 = ↑m / ↑n
eq2  : 2 * n ^ 2 = m ^ 2
lem1 : 2 | m
k : ℕ
eq3  : m = 2 * k
eq4  : 2 * n ^ 2 = (2 * k) ^ 2
eq5  : n ^ 2 = 2 * k ^ 2
lem3 : 2 | n
lem4 : 2 | m.gcd n
lem5 : m.gcd n ≠ 1
├ False
```

▼ Messages (1)

▼ IrrationalDemo.lean:13:0

Goals accomplished!

► All Messages

Sphere packing



In 2016, Maryna Viazovska, proving that the optimal packing of spheres in 8-dimensional space positions their centers on the points of the E_8 -lattice.

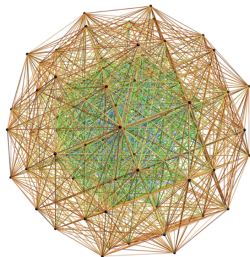
Annals of Mathematics **185** (2017), 991–1015
<https://doi.org/10.4007/annals.2017.185.3.7>

The sphere packing problem in dimension 8

By MARYNA S. VIAZOVSKA

Abstract

In this paper we prove that no packing of unit balls in Euclidean space $\mathbb{R}^8$ has density greater than that of the E_8 -lattice packing.



Visualization by J.G. Moxness (CC BY-SA 3.0).

Sphere packing



In 2016, Maryna Viazovska, proving that the optimal packing of spheres in 8-dimensional space positions their centers on the points of the E_8 -lattice.

A week later, she and four collaborators generalized these results to dimension 24.

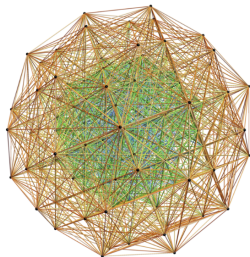
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Bad math?: scooping junior researchers



From “Mathematicians in the age of AI”

– Jeremy Avigad:

In early 2024, Sidharth Hariharan, then an exchange student from Imperial College ...began a project to formalize Viazovska’s proof of the optimality of the E8 lattice for 8-dimensional sphere packing. ...In the fall of 2025, things were going swimmingly. ...Several AI startup companies approached them seeking problems to test their products. The team embraced the use of AI, accepting AI generated “pull requests,” revising them to meet their contribution standards, and incorporating them into the codebase. ...

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Math, Inc.

← Back Home

Completing the formal proof of higher-dimensional sphere packing

Using Gauss, we have helped formally verify the sphere packing problem in dimensions 8 and 24 — certifying that the E8 lattice and the Leech lattice achieve the densest possible arrangements of non-overlapping spheres in their respective dimensions.

These results, originally proved by Maryna Viazovska and collaborators, earned Viazovska the Fields Medal at the 2022 International Congress of Mathematicians. This is the only formalization of a Fields Medal-winning result from this century ([GitHub](#)).

Then, a few weeks ago, Sid showed up at my office door, looking pale; he had just learned that a company known as Math Inc. decided to show off the abilities of its newest proving agent, Gauss, by completing a formal proof of the final result. ...they had not expected the company to throw computational resources at the project to obtain a splashy result ...as a “drive-by proving.”



Fermat's Last Theorem



In 1637, **Pierre de Fermat** claimed in a marginal note that he had a marvelous proof to the following statement in but provide no details:

Fermat's Last Theorem The equation $x^n + y^n = z^n$ has no integer solutions with $xyz \neq 0$ and $n \geq 3$.

In 1993, **Andrew Wiles** announced a proof, a modern tour-de-force using elliptic curves and modular forms.



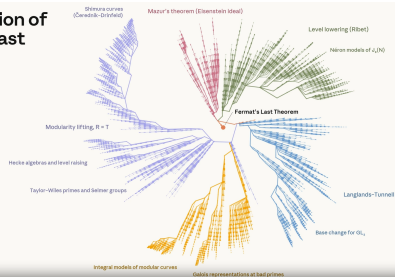
His proof contained a small mistake that took over a year to correct, with help from **Richard Taylor**. Their work was published in 1995 in the *Annals of Mathematics* in two papers totaling 129 pages.

Bad math?: wasted resources



We are sharing the first complete computer-checked proof of Fermat's Last Theorem. Claude worked largely autonomously over 11 days to write the proof in the Lean programming language. Below, we describe how the formalization was done and share some thoughts about what this work could mean for research mathematics.

Formalization of Fermat's Last Theorem



FLT: Anthropic has beaten me to it

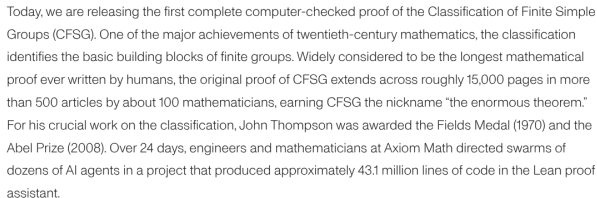
Posted on September 4, 2026 by [xenaproject](#)

I guess technically it was revealed to the world by [a coffee shop in Islington](#) on Insta, but an hour later it was [officially announced by Anthropic](#): one of their internal models, using the [prove2.me](#) platform, has formalized a complete proof of Fermat's Last Theorem (FLT) in Lean. This is the final theorem to be formalized in Freek Wiedijk's famous [list of 100 formalization challenges](#) and thus wraps up this 20-year-old benchmark. Congratulations to Anthropic!



What counts as “good math research” in an age of AI?

Formalizing the Enormous Theorem



Good math?: acknowledging human mathematicians

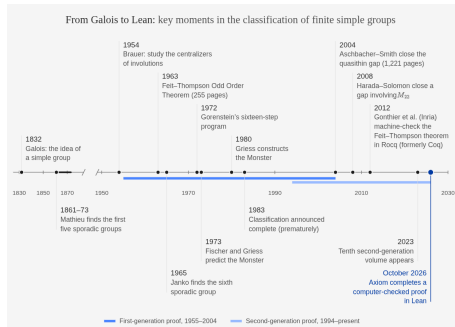


Acknowledgements

Our formalization is a small piece of a long history. The classification is the work of more than a hundred mathematicians, including Michael Aschbacher, Helmut Bender, Richard Brauer, John Conway, Walter Feit, Bernd Fischer, George Glauberman, David Goldschmidt, Daniel Gorenstein, Robert Griess, Koichiro Harada, Richard Lyons, Ulrich Meierfrankenfeld, Michael O’Nan, Charles Sims, Stephen Smith, Ronald Solomon, Bernd Stellmacher, Gernot Stroth, Michio Suzuki, John Thompson, Franz Timmesfeld, John Walter, and many others. While our formalization follows the first generation proof, our proof map draws heavily from the second generation volumes of Gorenstein, Lyons, Solomon, and Inna Capdeboscq. Our Lean formalization proof builds on Mathlib, which hundreds of contributors have made possible, and incorporates ~1.2 million lines of code from [QiuZhen-CFSG](#). We thank our external advisors Richard Lyons, Dan Nakano, and Ron Solomon for their time and expertise.

Core contributors: Dean Cureton, Vasily Ilin, Bhavik Mehta, Niels Voss

Other contributors: Rafael Cabral, Colin Defant, Erik Gregory, Aaron Hill, Letong Hong, Qinheping Hu, Dustin Jamner, Albert Jiang, Tadeusz Jordan, Andranik Kurghinyan, Kenny Lau, Jonathan Laurent, David Liang, Jannis Limperg, Simon Mahns, Brian Nugent, Connor Olson, Ken Ono, Eric Paul, Dhruv Rajan, Karun Ram, Charlie Ray, Ho Chung Siu, Ashvin A. Swaminathan, Jesse Thorner, Aleksey Tsaplin, Chenkai Wang



MATHEMATICS / MATH.GR – GROUP THEORY / hexagon:2618.00575v1

The Unbalanced Group Theorem

PRIMARYLY HUMAN-WRITTEN TEXT HUMAN UNDERSTANDING: ALL PARTS MATH.GR – GROUP THEORY

Contributed by Colin Defant, Ken Ono

Version 1 / Oct 27, 2026 / CC BY 4.0

Counting maps between spheres



An open challenge from June was to autoformalize the calculation of $\pi_3 S^2$, characterizing maps from the 3-dimensional sphere to the 2-dimensional sphere:

lean-eval Problems Submit ↻ ×

pi_3 of the 2-sphere is Z

[← All problems](#)

pi3_sphere_two_mulEquiv_int

Submitter: Kim Morrison.

Notes: The classical computation $\pi_3(S^2) = \mathbb{Z}$, with an explicit basepoint.

Source: Classical theorem in algebraic topology.

Informal solution: Use the Hopf fibration to identify the third homotopy group of the 2-sphere with the integers.

```
theorem pi3_sphere_two_mulEquiv_int (x : Metric.sphere (0 : EuclideanSpace ℝ (Fin 3)) 1) :
  Nonempty
    (HomotopyGroup.Pi 3 (Metric.sphere (0 : EuclideanSpace ℝ (Fin 3)) 1) x ==>
      Multiplicative ℤ) := by--
sorry--
```

Solved by
Not yet solved.

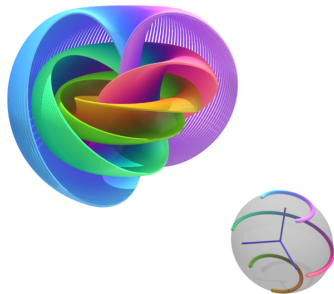


Image from an
animation by Niles Johnson

The Agda-Unimath library

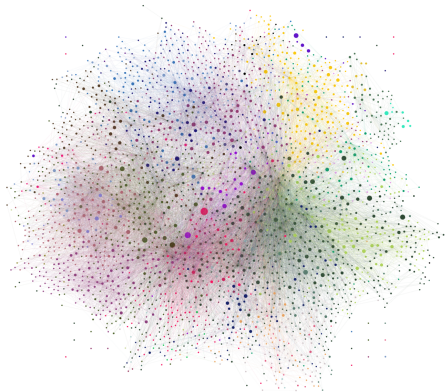


Welcome to the agda-unimath project. This is a community-driven effort aimed at formalizing mathematics from a univalent point of view using the dependently typed programming language [Agda](#).

The library project was created by [Elisabeth Stenholm](#), [Jonathan Prieto-Cubides](#), and [Egbert Rijke](#), and is currently being maintained by [Egbert Rijke](#), [Fredrik Bakke](#), and [Elif Uskuplu](#). Our goal is to create an online



encyclopedia of formalized mathematics containing an extensive curriculum of topics from a univalent point of view. We think libraries of formalized mathematics have the potential to be useful, and informative resources for both working and learning mathematicians. Our library is designed to work towards this goal, and we welcome contributions to the library within any topic in mathematics.



● foundation ● elementary-number-theory ● group-theory ● category-theory ● order-theory ● real-numbers
● synthetic-homotopy-theory ● metric-spaces ● univalent-combinatorics ● ring-theory ● linear-algebra ● commutative-algebra
● structured-types ● graph-theory ● orthogonal-factorization-systems ● trees ● globular-types ● species ● lists ● set-theory
● logic ● higher-group-theory ● finite-group-theory ● modal-type-theory ● complex-numbers ● universal-algebra ● reflection
● analysis ● finite-algebra ● type-theories ● functional-analysis ● domain-theory ● synthetic-category-theory
● wild-category-theory ● organic-chemistry ● literature ● spectral-theory

A dependency graph of the library, color coded by namespace. Fredrik Bakke. 2025 — perpetuity

Good math?: autoformalization for future infrastructure



arXiv

Mathematics > Algebraic Topology

[Submitted on 24 Aug 2026]

Autoformalizing the calculation of $\pi_3(S^2)$

Daniel Carranza, Chunyi Liu, Emily Riehl, Egbert Rijke

We report our findings and the results of our experiment of autoformalizing the homotopy type theoretic computation of $\pi_3(S^2)$ in agda-unimath using Codex.

The effort to import the
AI-generated formal proofs
back into its supporting
library continues:

4.3 Library impacts As noted in the introduction, we do not consider an autoformalization project to be completed until it makes a commensurable contribution to the supporting library, in this case agda-unimath. The raw Codex generated code in our repository does not yet meet the standards for an agda-unimath PR, much less the standards of the library. It is insufficiently documented, insufficiently explained, and far too verbose. The formalization code also needs thorough review by us first, and later by library maintainers.

One motivation for writing this report is to facilitate communication with the maintainers of the agda-unimath library. We hope to discuss the possibility of extracting library-quality code to contribute to the library over a series of PRs in a way that is sensitive to the amount of human labor that the review process will require, in particular by contributing our own efforts to the refereeing process. As we view this to be of paramount importance to the evolving interactions between generative AI and computer formalization of mathematics, we plan to update this preprint with the results of our planned future conversations with the broader agda-unimath community.