

Number theory, sphere packings, and bridges

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Tulane University

January 7, 2026

From Fairfield, IA

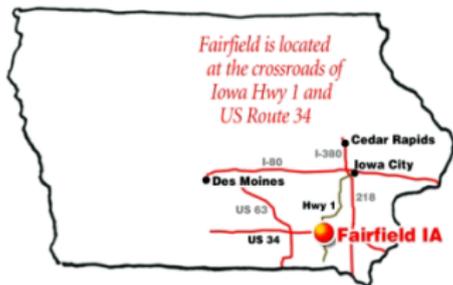


Figure: From <http://www.jeffersoncountyiowa.com/>.

Interested in civil engineering



Figure: Clifton Suspension Bridge, Bristol, England.



- Started as civil engineering major in 2011
- Switched to math by end of freshman year
 - Like proving things

ROSE-HULMAN INSTITUTE OF TECHNOLOGY

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The logo for Rose-Hulman Institute of Technology, featuring the text "ROSE-HULMAN" in a large, bold, white sans-serif font above "INSTITUTE OF TECHNOLOGY" in a smaller, white sans-serif font, all contained within a dark red rectangular background.

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UNIVERSITY | NEW BRUNSWICK

- Mathematics Ph.D. program (2016–2022)



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- Research
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 - Instructor and TA for Rutgers courses (including precalculus, Calculus II, probability, & linear algebra)
 - Rutgers Math Teaching Group



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- Math outreach
 - Rutgers Math Teachers' Circle
 - Julia Robinson Mathematics Festival (JRMF)
 - San Francisco Math Circles



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 - Triangle Math Teachers' Circle



- National Science Foundation (NSF) Mathematical and Physical Sciences Ascending Postdoctoral Research Fellow

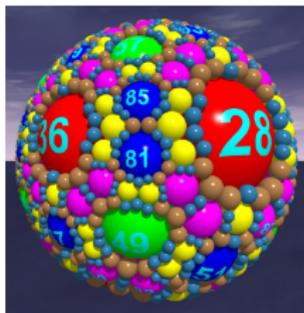


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- Research
- Math outreach
 - Visit schools
 - Boys at Tulane in STEM (BATS)
& Girls in STEM at Tulane (GiST)

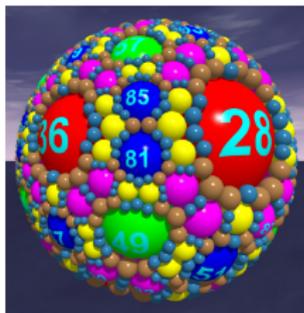
Kleinian sphere packings and the integers



Label on sphere:
 $\text{bend} = 1/(\text{signed radius})$



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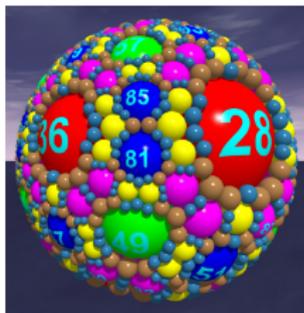
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Kleinian sphere packings and the integers



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Which integers appear as bends?

(Strong asymptotic) local–global principles

Research goal: Prove (strong asymptotic) local–global principles for certain integral Kleinian sphere packings. That is, prove:
If m is admissible and sufficiently large, then m is the bend of an $(n - 1)$ -sphere in the packing.

Definition (Admissible integers)

Let \mathcal{P} be an integral Kleinian sphere packing.

An integer m is *admissible (or locally represented)* if for every $q \geq 1$

$$m \equiv \text{bend of some } (n - 1)\text{-sphere in } \mathcal{P} \pmod{q}.$$

Progress towards (strong asymptotic) local–global conjectures for Kleinian sphere packings

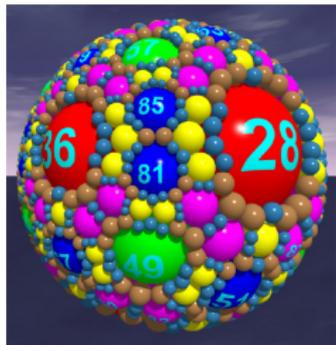


Figure: (Strong asymptotic) local–global principle proven for Soddy sphere packings by Alex Kontorovich in 2019 (arXiv 2012).

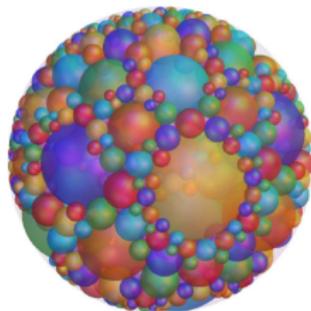


Figure: Partial local–global results for orthoplicial sphere packings independently proven by Kei Nakamura (arXiv 2014) and Dimitri Dias (arXiv 2014). I am also working on this.

A congruence restriction for orthoplicial sphere packings

Theorem (Nakamura, 2014; Dias, 2014)

For a primitive integral orthoplicial sphere packing \mathcal{P} , there exists $\varepsilon(\mathcal{P}) \in \{\pm 1\}$ such that the bend b of any sphere in \mathcal{P} satisfies

$$b \equiv 0, 2, \text{ or } \varepsilon(\mathcal{P}) \pmod{4}.$$

Example



Every bend in this packing is congruent to 0, 1, or 2 (mod 4).

Local–global principle for orthoptical sphere packings

Theorem (J., 2026+)

The bends of a fixed primitive integral orthoptical sphere packing \mathcal{P} satisfy a (strong asymptotic) local–global principle.

That is, there is an $N_0 = N_0(\mathcal{P})$ so that, if $m > N_0$ and m is admissible, then m is the bend of a sphere in the packing.

Example



In this orthoptical sphere packing, every sufficiently large $m \equiv 0, 1, \text{ or } 2 \pmod{4}$ is the bend of a sphere in this packing.

Proof uses Möbius transformations on spheres, quadratic forms, and the circle method in analytic number theory.

Creating metaphorical bridges with welcoming math environments



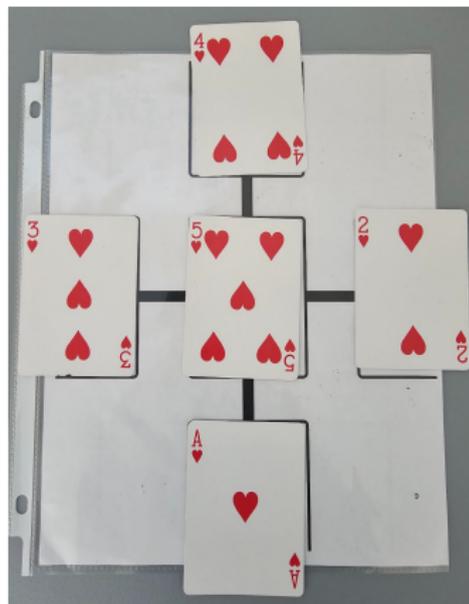
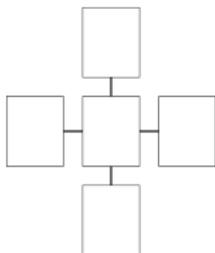
Math activities with Tulane Center for K–12 STEM Education

- Saturday workshops with 5th–7th graders and their teachers
 - Boys at Tulane in STEM (BATS)
 - Girls in STEM at Tulane (GiST)
- In-schools program in classrooms
 - 2nd–7th grade
 - I've been to 6 different public schools in New Orleans.



Activity: Magic Flowers

- Arrange the numbers 1, 2, 3, 4, & 5 on the flower.
- A flower becomes **magic** when each group of numbers in a line has the same sum.

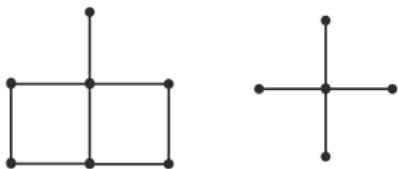


Activity available at <https://jrmf.org/puzzle/magic-flowers/>
Worksheet available at <https://ednajones.com/resources.html>

Activity: Doodles & Doors

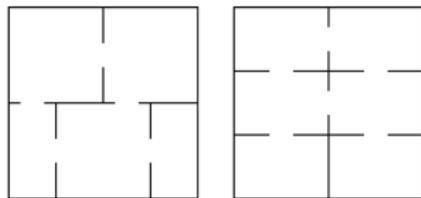
- Doodles

Which doodles can you trace without picking up your marker and without retracing any lines?



- Doors

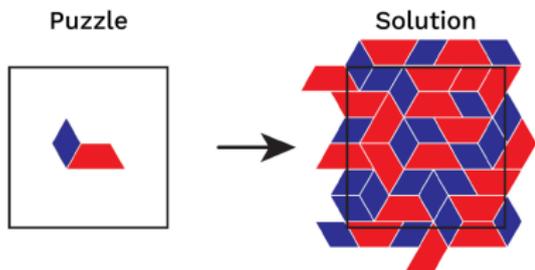
For each set of rooms, can you trace a path that goes through each doorway exactly once?



Worksheet available at <https://ednajones.com/resources.html>

Activity: Tile with Style

- Start by making the puzzle's design in the center of your paper.
- Try to cover the rest of the paper using only the shapes in that design.



Activity available at <https://jrmf.org/puzzle/tile-with-style/>

Math for All in New Orleans

- Encouraging first math conference experience
- Talks about math & experiences
- Poster session
- Puzzles & activities



Figure: Math for All in New Orleans in 2025

This year's dates: April 10–11, 2026

Website: <https://www.mathforallconference.com/>

Thank you for listening!

