Swat Math/Stat Research

Summer 2023

SWARTHMORE

Our Awesome Panelists!

- Deven Ayambem, class of 2024
- Francesca Cantor, class of 2025
- Andrew Harsh, class of 2023
- Sherry Huang, class of 2023
- Amy Liu, class of 2024
- Lizbeth Zarate-Hernandez, class of 2024

How to use this document:

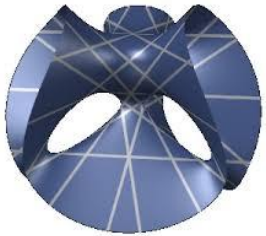
Faculty members in the math/stat department who may have Summer 2023 research projects have each made a slide or two to give you a short overview of their work and potential ideas for what students could work on. Some have also included further reading and next steps for potential research assistants.

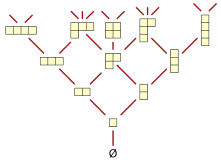
Take a look at the following slides, check out the linked resources, and reach out to any professors that you might be interested in working with!

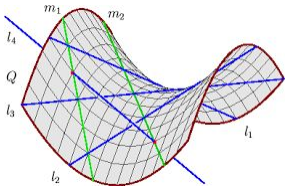
The last page has links to some outside opportunities. If you know of more, let me know and I'll add them to the list!

(Note: demand for math/stat summer research far exceeds the supply of positions available, and most funding will be through the college's funding application, which happens in February or later)

Algebraic Combinatorics and/or Algebraic Geometry -- Prof. Linda Chen







My research is at the interface of algebraic geometry, algebraic combinatorics, and representation theory:

- the translation of problems in geometry to problems in algebra and combinatorics,
- combinatorial structures such as partitions and permutations,
- families of symmetric polynomials.

I *might* supervise undergraduate research this summer. If interested, email lchen@swarthmore.edu with a paragraph about your background and potential interest.

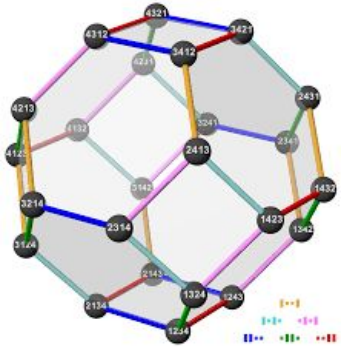
Ideal background: at least two of Math 67/Math 69/Math 102.
Bonus background: programming experience, any math seminar (Math 101/102/103/104/105).

Quick reference and video.

Approximating Ranked Choice Voting With Spatial Voting

In *ranked choice voting* each voter ranks all the candidates by preference. In particular, *spatial voting* assumes that all candidates and voters are points in n-dimensions. Voters rank candidates by order of proximity. If there are k candidates then no matter how the voters rank them, we can always fit this to a spatial voting model in R^k.

- What are the theoretical limitations of spatial voting in low dimensions?
- What about in real life with real data? How many dimensions are needed to model the new york mayoral primaries?
- Can we measure how well a spatial model approximates voters rankings even if it's not perfect?



I suspect the permutahedron will show up…

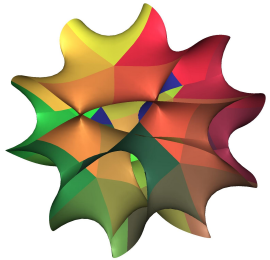
Flavor notes: algebraic combinatorics, data science, voting theory, hints of nutmeg.

No particular background is required but we're all about permutations and proofs.

For more info contact Lucas VanMeter (lvanmet1@swarthmore.edu)

Geometry and Physics-Prof. Ralph Gomez

Research Project: The universe might very well be 10 dimensional (4 space-time plus 6 extra dimensions) although there is not yet any experimental evidence for this. However, there is a fascinating symmetry associated to spaces that live in these extra 6 dimensions. That symmetry is called *mirror symmetry*. I would like to use some computational techniques and ideas from mirror symmetry to explore the creation of new mathematical spaces in odd dimensions for which the curvature of these spaces is very specific. We will likely specialize in dimensions five and seven.



Ideal background: A course in abstract algebra and a seminar in geometry or analysis is preferred.

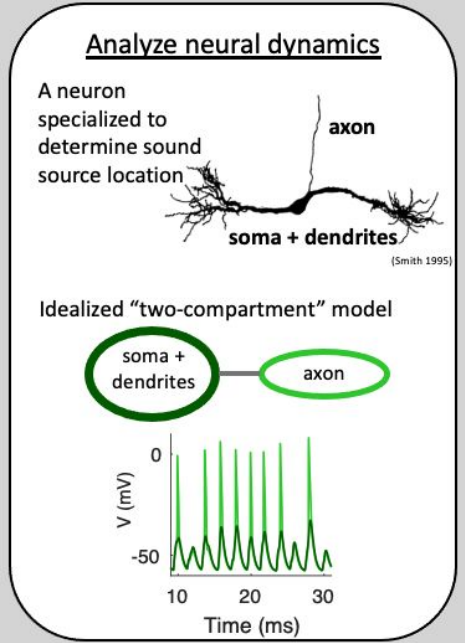
Contact: I *might* supervise two students for summer of 2023 who would like to work on such a project. Please email me at rgomez1@swarthmore.edu if you are interested or have any questions!

Mathematical neuroscience and nonlinear dynamics -- Prof. Josh Goldwyn

Mathematics can be used in fascinating ways to study the functioning of the brain.

I often study brain cells (neurons) that have highly specialized dynamics to process temporal features in sounds (in the auditory system).

Research project this summer: Model how specialized auditory neurons may change during periods of hearing loss, and understand how these changes may impact a listener's ability to determine the spatial location of sound sources.



Mathematical topics you will learn and use may include:

Differential equations modeling, numerical simulations,
analysis of nonlinear dynamical systems, random processes

Helpful (BUT NOT REQUIRED) coursework includes: Math 44 or Math 66 or CS 21.

Enjoyment of computer coding is important.
No required background in biology & neuroscience,
but you should find it *interesting*

Additional information on my website:

https://www.swarthmore.edu/joshua-goldwyn/summer-projects

Email me with questions and/or interest:

jgoldwyn@swarthmore.edu

Statistical Paleontology — Prof. Steve Wang

I develop statistical methods for analyzing data from paleontology, mass extinctions, evolution, and conservation biology.

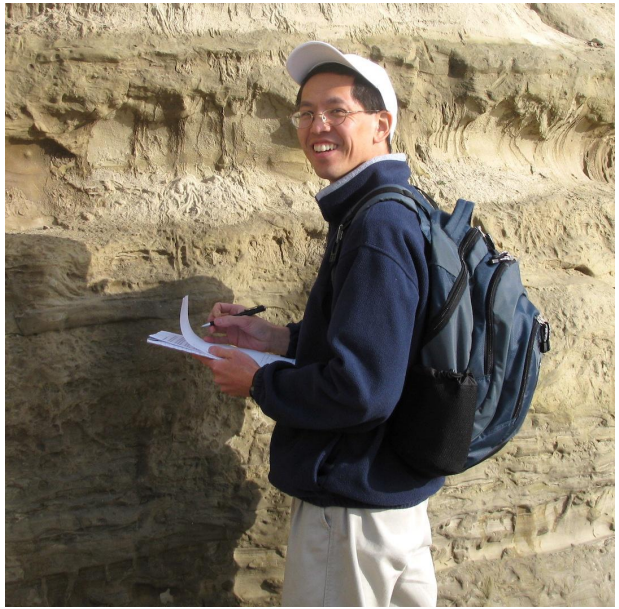
I am not yet sure what specific projects we'll be working on this summer, but you can read brief descriptions of work by previous students here: http://www.swarthmore.edu/NatSci/swang1/personnel.html

The most important qualities I am looking for are persistence, perseverance, attention to detail, and skill in debugging. My work mainly involves computer programming, so you should have taken CS 21 or an equivalent. (CS 35 is helpful but not necessary.) The ideal statistical preparation would be Stat 51, but Stat 11 could work as well. No experience in paleontology is expected.

If you're interested, please send a resume/CV to swang1@swarthmore.edu.

You can find more information on my research here: http://www.swarthmore.edu/NatSci/swang1/research.html

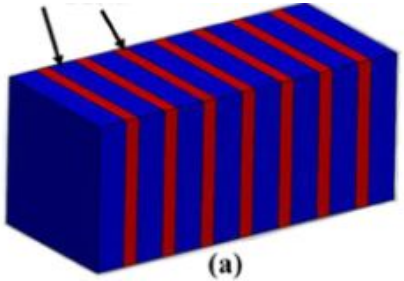
Feel free to ask if you have any questions!

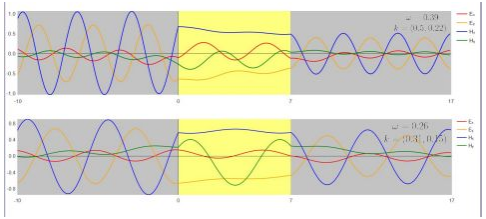


Applied Mathematics - Professor Robert Viator

My research is centered on the intersection of differential equations (ordinary and partial), eigenvalue problems, and applied mathematics. A current project with colleagues at LSU and FIT is the development and implementation of a GUI for modeling electromagnetic waves in layered media. We are modeling physical phenomena including scattering, resonance, Faraday rotation, guided modes, dispersion relations, and more, all with minimal user input and knowledge.

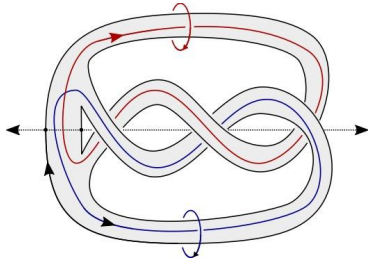
Background required – Math 43/44; some experience in Python or Matlab is helpful, but not necessary



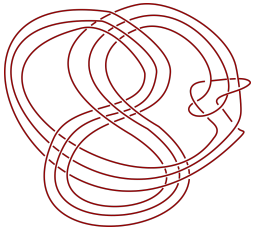


To work with me: contact me at rviator1@swarthmore.edu describing your background and interest.

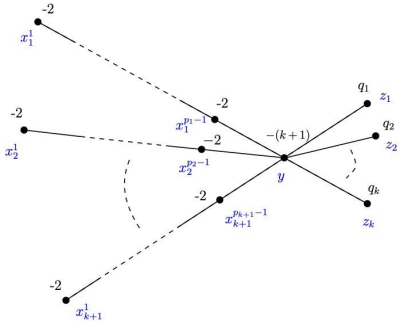
Knot theory and low-dimensional topology
Prof Allison Miller



Question: What can algebraic quantities (associated numerical values, polynomials, counts of solutions to systems of equations, ...) tell us about the 4-dimensional properties of knots?

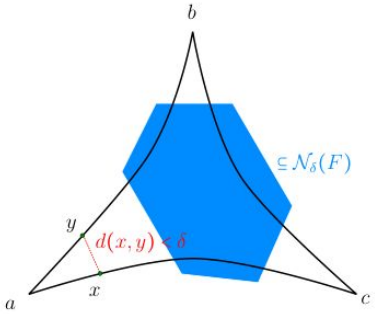


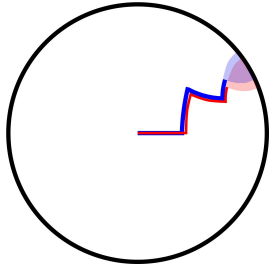
All projects require linear algebra and some proof-writing experience. For some projects, modern algebra and/or coding skills will be useful.



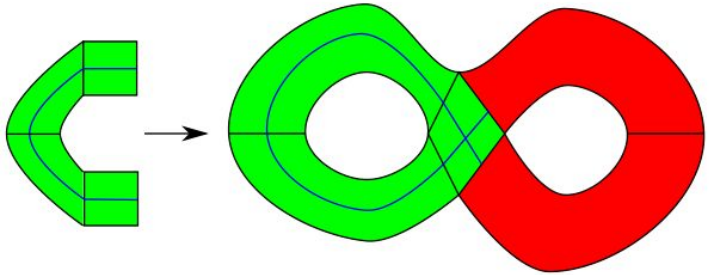
Email amille11@swarthmore.edu if you're interested and/or have questions!!

Hyperbolic geometry in group theory and neuroscience
Prof Teddy Einstein





Is there a natural way to relate neural activity to similarities/differences in perception? One way we might hope to do so is using hyperbolic geometry. I am also interested in using hyperbolic-like geometry to study groups, manifolds and cubical complexes.



Neuroscience projects require (multivariable calculus + coding) or a proof based course, group theory requires algebra

Email eeinste1@swarthmore.edu or drop by SC140 if you're interested and/or have questions

Applied Latent Variable Analysis with Professor Lynne Steuerle Schofield (and friends!)

- Theoretical Statistical Question: How do we measure “immeasurable” (or not directly measurable) latent variables such as intelligence, depression, conscientiousness, and/or quality of life?
- Applied Statistical Question: How can we help to improve a residential drug treatment program in Chester?
- Answer to both: Work with me and a team of professionals looking to see if a “Quality of Life” index provides valuable information to City Team’s Residential Drug Treatment Program that helps them evaluate their services and make thoughtful changes.

Coursework required: Stat 11 and Stat 21 (CS21 preferred)
Email: lschofi1@swarthmore.edu if you are interested!

Swarthmore Summer Scholars Program Math Mentor

As we have learned in the 8 years of the Program, the Student Mentors are the 'secret sauce' to the S^3P recipe for a successful program. The job is a combination of teaching assistant and resident assistant. Please direct any questions to

Professor Ben Geller, S^3P Director bgeller1@swarthmore.edu

https://www.swarthmore.edu/summer-scholars-program/mentor-information

Two student Math Mentors will be hired (along with 4 others who will support Writing and CS) and will work closely with Academic Support Coordinator Laura Dandridge and Professor Cheryl Grood. Math Mentors should have completed Math 15 and Math 25 and do not need to be STEM majors or minors.

Responsibilities: Support 16 summer scholars during the 4 weeks of the summer Program: serve as subject matter teaching assistants (TAs) to support the faculty who will be teaching; run the 5 study hall sessions each week; serve as RAs (even during the virtual program), providing tours, talking about resources on campus to support academics, physical and mental health, social activities; undergo 2 weeks training before the Program formally begins; attend and report at weekly S^3P staff meetings during the summer; follow up with the Director in the week following the summer Program

Strong candidates: have demonstrated knowledge in the subject area that they will support; have strong commitment to inclusive diversity in the Swarthmore community; are dependable team members with strong communication skills; have awareness of first-gen/low-income (FLI) student challenges and opportunities

External Math/Stat Research Opportunities

The NSF funds a number of REU's in the mathematical sciences across the US. The AMS also maintains a list of REU opportunities. (Note that NSF-funded positions are restricted to US citizens or permanent residents)

The AMS also has a list of possible summer programs: https://www.ams.org//opportunities

Summer@ICERM program at Brown University

The Summer Institute in Biostatistics is an NIH-funded program across six different universities

Stanford Population Health Summer Research Program is a virtual program for under-represented and historically excluded students in the health sciences with a focus on quantitative methods for population health

** Feel free to leave a comment with any other opportunities, and I will add them to the document 😊