MEGL projects, Fall 2020

Apply at `http://meglab.wikidot.com/opportunities` by August 10

About MEGL The Mason Experimental Geometry Lab, housed at L106 Exploratory Hall, involves undergraduate students, graduate students, an dfaculty in cutting-edge mathematics projects; and provides a research entry point for future mathematicians. The facility provides computation and visualization equipment, including high-speed and high-memory computers, virtual reality environments, and 3D printers.

Expectations Undergraduate MEGL members sign up for 3 credits of independent study (Math491) and commit 10 hours/week to MEGL work. Students are expected to attend weekly meetings, work independently and with their group, and to help with community outreach. Teams will present their work at the mid-semester and end-of-semester meetings.

COVID note During the fall semesters all projects will run online. Remote access to computing equipment will remain available, and some limited access to MEGL equipment may be possible.

Professor Daniel Anderson

Mathematical modeling of capillary rise in porous materials The phenomena of capillary rise of fluid in porous materials is central to many problems in fluid mechanics and has a broad range of applications. Mathematical models describing capillary rise account for the various physical processes involved and are often formulated using differential equations. This project will explore predictive mathematical models and compare results with published capillary rise data as well as with data obtained from simple experiments using familiar porous materials.

Background/Prerequisites: Interest in physics and familiarity with differential equations. Numerical skills (e.g. Matlab) would be helpful as well.

Professor Rebecca Goldin

Only one Dr. Goldin's projects is expected to take place in Fall 2020, to be determined by student interest. Make sure to indicate a backup project in your application.

Combinatorics of Cohomology Rings of Peterson Varieties The Peterson variety is a subvariety of the flag variety, G/B where G is a semi-simple Lie group and B is a Borel subgroup. In the case that G is $Sl(n, \mathbb{C})$ and B is upper triangular matrices, a GMU grad student and I recently found a beautiful combinatorial formula for multiplication in the cohomology ring of the Peterson variety using a distinguished basis. This project aims to generalize those computations to other Lie types by mucking around in the combinatorics.

Required background: Math 321 and Math 290 are prerequisites for this project. Its generally helpful if students have had a course in combinatorics, algebraic geometry, Lie groups, and/or Algebraic Topology.

Communication about the Science and Data of COVID-19 Media representations of COVID-19 have alternately promoted public understanding and reinforced public misunderstandings of the science behind COVID-19. We will do an exploration of how we communicate about multiple COVID-related topics such as positive tests, death rates, R0, hospital capacity, data collection, public phasing and more. We will examine how choices both scientists and the media make make in language, data visualization, and model descriptions create different narratives about the virus, especially in relation to the uncertainty involved with outcomes. Depending on interest, experience and expertise, we will create some data visualizations, write up guidelines/suggestions for media coverage, and/or analyze excellent and poor media coverage. Some of this work is based on Dr. Goldins extensive work with journalists over the past 15 years in covering news that uses statistical concepts.

Prerequisites: It is recommended (but not required) that students have had some of the following:

- STAT 200 or AP Statistics;
- Journalism;
- One college-level writing course;
- Experience with R or with data visualization;
- Experience in anything related to public health.

Students will be working together so only enthusiastic team players should apply!

Professor Matthew Holzer

Geometry of Machine Learning This is an exploratory project aimed at understanding how neural networks operate. We will read some papers and try to construct simple examples that illustrate how these networks work as classifiers to separate data into two or more groups. The project will involve both theory and numerical implementation. Interested students should be willing to be involved in both aspects of the project.

Professor Anton Lukyanenko

Visualizing Thurston geometries in VR One way to study non-Euclidean geometries is to build tools that give us a peak into their shapes and physics, allowing us to explore their peculiarities and giving us new geometric questions to explore. In this project, we will continue work on an archery simulation in Heisenberg (nil) geometry, demonstrating several variations on the geometry. If time permits, we will move on to other geometries, including hyperbolic space and sol geometry. While some students are returning, we are excited to welcome new team members.

Background: completion of Math213 or equivalent, some familiarity with programming (we will be using C# and Unity, but you are not required to know them in advance), and an eagerness to explore new geometries.