Fall 2019 Research Projects

at the Mason Experimental Geometry Lab involving Undergraduate and Graduate students

Visit http://cos.gmu.edu/megl to apply.

Decisions in finance from the knapsack problem point of view

Prof. Geir Agnarsson

The Knapsack Problem is a well-known Integer Program Problem that is NP complete, even the simple decision version of it. However, in the financial world there are many sensible assumptions that can make the problem of optimizing a portfolio using the Knapsack problem feasible and solvable in polynomial time. This project will be about how to optimize such a portfolio using some sensible restrictions for the Knapsack problem.

Requires: Math213 or Math125

Instability spreading in spatially extended systems

Prof. Matt Holzer

This project will study the spread of instabilities across spatially extended networks modeled by lattices or networks. Examples include the spread of invasive species or epidemics. The goal is to derive general principles to describe the dynamics of these spreading processes and obtain predictions regarding their speed. Work will involve a combination of analysis and numerical simulations.

Requires: Differential equations and linear algebra (at the level of 214/203) and a knowledge of or willingness to learn Matlab.

Statistics in Deformations of Large Knots

Prof. Sean Lawton

A knot is an embedded circle in Euclidean 3-space. The complement of a knot is a geometric object that looks locally like Euclidean 3-space. A "large" knot is one that allows for an "essential" embedded surface in its knot complement. This project is all about statistics of the "wiggle room" that large knots have. In particular, in https://mathoverflow.net/a/323674/12218 Dr. Lawton determines that there exist large knots with only 1 degree of wiggle room (it is known that ALL small knots have this property). In this project, we will be gathering data on which knots in the SnapPy Census have 1 degree of freedom, and which have more. We will also 3D print knots and their "fundamental domains" (when they are hyperbolic).

Requires: Math290

Geometry of Self-Driving Cars

Prof. Anton Lukyanenko

Path planning for self-driving robots requires an accurate mathematical model of their motion. In the Dubins model, a vehicle is given coordinates (x,y,theta) representing its center and direction, and is allowed to move only forward, with a turning radius constraint. Getting to a new destination requires a combination of straight motion and turns, and can be done in five such moves. In this project, we will explore the 3D configuration space and the sub-Riemannian geometry of the Dubins car to quickly compute optimal trajectories—and then proceed to study the Reeds-Shepp and asymmetric Reeds-Shepp models. The project will involve some 3D printing and programming.

Requires: Math213

A computation of test ideas of big Cohen-Macaulay modules

Prof. Rebecca R.G.

Test ideals are a useful tool for studying singularities of commutative rings and their corresponding geometric objects. This project involves computing examples of test ideals coming from big Cohen-Macaulay modules using the programming language Macaulay2. You will learn a lot of commutative algebra as well as a bit of programming.

Requires: Math290, Linear Algebra, interest in programming. Preferred: Abstract Algebra, small amount of programming experience.

Join the MEGL community!

The Mason Experimental Geometry Lab, housed at L106 Exploratory Hall, involves undergraduate students, graduate students, and faculty 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.

Each project (designated entry, intermediate, or advanced) runs for one semester, with the possibility of continuation.

Undergraduate MEGL members sign up for 3 credits of independent study and occasionally help run MEGL's community outreach at nearby schools.

Applications will be considered on a rolling basis. Apply early for best consideration. The list of projects may be updated over the summer; apply to receive updates.