MEGL Projects Fall 2021

For best consideration, apply at https://megl.science.gmu.edu/projects/fall-2021/ by August 1.

About MEGL 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.

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 semester, we expect projects to resume in person meetings. If you are not able to return to in person instruction, we can accommodate this. Just let us know.

Professor Daniel Anderson

The stability of icebergs and other floating objects Computing quantities like the center of mass, the center of buoyancy, and another quantity called the metacenter. Archimedes' Principle plays a role here. This project will involve predicting stability and floating orientations of shapes with simple and complex geometries using numerical and analytical approaches Some experimentation will likely be involved as well.

Background/Prerequisites: Math 213. Some numerical experience (or willingness to learn) will be useful.

Difficulty level: Entry level

Professor Rebecca R.G.

Cores and hulls of ideals of commutative rings The integral core of an ideal of a commutative ring is used to determine key properties of the ideal and the ring. In this project, we will explore other types of cores and hulls, computing examples both by hand and in the programming language Macaulay2. We will work over commutative rings where we can describe most or all ideals in the ring.

Background/Prerequisite: Completion of Math 300, Introduction to Advanced Mathematics, formerly Math 290. Preferred background: Math 321, small amount of programming experience in any programming language

Difficulty level: Quite difficult

Professor Padhu Seshaiyer

Mathematical Modeling, Analysis and Control for Understanding the Spread of infectious diseases In this work, we plan to consider new compartmental models that will attempt to capture the dynamics of the spread of infectious diseases such as COVID-19 and its variants as well as impact of vaccination against the spread. Building on knowledge from the current nature of the spread, data available on transmission rates, seasonality, social behavior and infectious disease models our goal will be to come up with a family of models that help to provide deeper insight into the nature of the dynamics. Along with the development of these models the mathematical research will also focus on deriving rigorous mathematical expressions for basic reproduction number, performing mathematical stability analysis as well as conducting an optimal control applied to the infectious disease models. We also hope to validate the models against benchmark data and parameters available from the CDC and also use data of infected cases to estimate the parameters through parameter estimation techniques.

Background/Prerequisites: Completion Math 214, Differential Equations.

Difficulty level: Entry level

Professor Sean Lawton

Constructing and Reverse Engineering Moduli Spaces Students will play, construct, and identify moduli spaces. 3D printing, and computer experimentation/visualization will be part of the project. However, students will be able to make their moduli spaces out of anything they want: wood, clay, string etc. There is no definitive goal to this project: we will simply have fun exploring the idea of moduli space ("space of spaces") creatively. As many moduli spaces are in terms of the subject Algebraic Geometry, students on this project are strongly encouraged to take Math 494 (Algebraic Geometry) in Fall 2021 in parallel.

Background/Prerequisites: Completion of Math 300, formerly Math 290 with a B or better.

Difficulty level: Entry level

Professor Harrison Bray

Mathematical Outreach MEGL offers outreach activities to the community every semester. To fulfill our mission of outreach, we need your help. Participants will deliver, refine and help develop mathematical outreach activities which inspire a passion for mathematics. Check out our website for examples of MEGL outreach activities.

Background/Prerequisites: A passion for mathematics

Difficulty level: Entry Level

Professor Rebecca Goldin

Combinatorics of Cohomology Rings of Peterson Varieties We will be looking at a ring map associated to the inclusion of the Peterson variety into the flag manifold, mainly the induced restriction

in the S^1-equivariant cohomology ring. We will study the restriction of geometrically represented classes called Schubert classes to the Peterson variety.

Background/Prerequisite: Completion of Math 321, Abstract Algebra.

Difficulty level: Challenging