MEGL Projects Spring 2021

For best consideration, apply at http://meglab.wikidot.com/opportunities by December 11.

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 spring semester, 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.

Difficulty level: Moderately difficult

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 COVID-19 In this work, we plan to consider new compartmental models that will attempt to capture the dynamics of the spread of COVID-19. 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 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 COVID-19 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: Challenging

Professor Rebecca Goldin

Combinatorial formulas for the Equivariant Cohomology 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/Prerequisites: Completion of Math 321, Abstract Algebra.

Difficulty level: Challenging

Professor Anton Lukyanenko

Mathematical Visualization We will work on visualizing different ideas in mathematics, ranging from solutions to PDEs to hyperbolic geometry. Our focus will be on understanding and improving on previous MEGL visualization projects, and there will also be space to visualize other ideas we come across.

Background/Prerequisites: Completion of Math 213, Multivariable Calculus and an interest in mathematical visualization. Knowledge of some programming (especially C# and Unity) preferred but not required.

Difficulty level: Challenging