

Personal Statement

My interest in the UC Davis REU stems from my strong affinity for physically and biologically motivated problems in mathematics. Several of my research and classroom experiences revolve around this theme. Most recently, I worked on a mathematical model for special cells in the bone known as osteocytes with Madison Albert and Drs. Jared Barber and Luoding Zhu as part of the Summer 2021 Indiana University-Purdue University Indianapolis (IUPUI) applied mathematics REU. The overarching goal of the project was to create a three-dimensional model of an osteocyte and its surrounding fluid to better understand how the cells sense and respond to forces. The solid components of the cell were modeled as a network of damped springs, and I worked on computing the resulting forces on the cell. After computing the forces, we obtained a large system of differential equations that we numerically integrated using Matlab to determine the cellular dynamics in response to compression forces. We also used Matlab to visualize these dynamics. The results of the REU are currently being compiled into a paper that we plan to publish this year and I have also presented the results at 4 different conferences.

In Spring 2021, I worked on the more macroscopic problem of modeling the motion of aquatic animals such as archer fish at a water-air interface as part of Dr. Leah Mendelson's Flow Imaging Lab at Mudd (FILM). I focused on modeling the oscillatory motion of a tailfin as an inverted pendulum at the interface between two media. In order to tackle the original problem, which was unwieldy and involved several degrees of freedom, I analyzed the dynamics of a system with reduced degrees of freedom. I used Lagrangian mechanics to tackle this complex problem. Since a pendulum at an interface feels different forces from each of the media, I separated the pendulum into a water-submerged section and an air-submerged section. This distinction made the problem more tractable, and I was able to derive the equations of motion of the system and conduct an equilibrium point and stability analysis.

In Fall 2020, I explored problems in the calculus of variations through my Theoretical Mechanics class, as well as my independent study of graduate level calculus of variations under the mentorship of Dr. Dagan Karp. My independent research complemented the class by focusing heavily on the mathematical rigor of many of the results used in the Theoretical Mechanics class. Using Mark Kot's "A First Course in the Calculus of Variations" as a guide, we studied topics such as geodesics, Lagrangian and Hamiltonian mechanics, Lagrangian densities, and isoperimetric and holonomic constraints. These tools were used in a computational project on the Brachistochrone problem with kinetic friction. The conventional Brachistochrone problem searches for the trajectory that minimizes the time of travel between two points on a vertical plane and assumes that there are no non-conservative forces like friction and drag. I decided to examine a modification of the problem that accounts for kinetic friction. The first half of the project used calculus of variations to solve for the shape of the trajectory, while the second half of the project used Lagrangian analysis, with the help of Mathematica, to analyze the dynamics of the system over time.

The UC Davis REU is a perfect opportunity to apply the mathematical and computational skills I have gained from previous experiences to new and interesting problems in applied mathematics. I especially look forward to the Rotating fluid dynamics experiments and partial differential equations project at UC Davis. All of my research experiences, from osteocytes to tailfins, have been theoretical or computational in nature. At FILM, the opportunity to experience experimental fluid dynamics was hampered by an online semester. Given the importance of experimental work in the testing and modification of theoretical models, the project is an opportunity to finally dive into experimental work in fluid mechanics. At IUPUI, osteocytes were surrounded by interstitial fluid, and the flows were smoother and not very turbulent. With the Rotating Fluid Dynamics project, I am excited to make the jump to larger scales where flows can become quite chaotic. While macroscale fluid mechanics are new and interesting, I equally look forward to extending my knowledge of fluid dynamics at a cellular level with the Multiscale modeling of flagellar regulation mechanisms project. During my REU at IUPUI, we focused primarily on the solid cellular components of the model, so I am enticed by the prospect of instead studying the fluidic components of cellular locomotion. Since Summer 2021, I

have taken courses in partial differential equations and mathematical models in fluid dynamics, and both these projects are a chance to combine my new coursework with experiences in microscale and macroscale fluid and cellular dynamics. Furthermore, the exposure to these lines of research under the guidance of faculty at large research institutions with doctorate programs would be immensely valuable as I prepare for PhD programs in Applied Mathematics.

Statement on Diversity, Equity, and Inclusion

I believe that everyone, regardless of age, gender, ethnicity, or background, is capable of excelling in mathematics and science. Throughout my time at Harvey Mudd College, I have been involved in projects relating to equity in STEM education. I was a group leader for the Claremont Colleges Science Bus, an initiative in which college students teach supplementary science and mathematics lessons at elementary schools in the Pomona Unified School District. Many of these schools lacked a developed science curriculum due to budget cuts, and as educators it was our job to ensure that students, especially those of underrepresented backgrounds, were exposed to topics in STEM. I was also involved with Gateway to Exploring the Mathematical Sciences, a program at Harvey Mudd in which a professor teaches mathematics to high school students. The program is free, and as a volunteer teaching assistant, my role was to ensure that learners who were new to mathematics did not feel left behind in a classroom of diverse mathematical backgrounds. At Harvey Mudd, we are privileged to have an even gender split among our STEM majors, and throughout my classes I have been grateful for the diverse array of ideas and experiences represented. Faculty at Harvey Mudd have a strong commitment towards diversity and equity in mathematics, and I hope to bring the same commitment to the UC Davis REU. I resonate with the role of REUs as a means of making research accessible to traditionally underrepresented groups in mathematics, and I believe that the unique backgrounds of my peers are crucial for creating a healthy, respectable, and fruitful research environment.