Haoyu Zhang Ph.D. in Mechanical Engineering, 2024 Spring

Personal Statement

I'm interested in Columbia University's Mechanical Engineering PhD program because I have a strong desire to collaborate with Dr. Gerard Ateshian. My research interest revolves around investigating the mechanical properties of articular cartilage to advance diagnostics and treatment for cartilage-related disorders. This involves a specific focus on mechanisms of wear and resultant structural changes to articular cartilage. I plan to leverage computational modeling, advanced imaging techniques, and experimental methods to enhance our understanding and improve patient outcomes in musculoskeletal health. This research direction aligns perfectly with Dr. Ateshian's work on musculoskeletal soft tissue mechanics, with a particular emphasis on cartilage mechanics, lubrication, and tissue engineering. Therefore, I believe it's in my best interest to pursue my PhD under his guidance.

My enthusiasm for biomechanics stems from my undergraduate senior capstone project titled "Marine-Life-Friendly Propulsion System." In this project, I collaborated with four teammates to develop a propulsion system that prioritized low noise levels, marine life safety, and energy efficiency. It was during this project that I first became intrigued by biomechanics and gained an understanding of how biomechanical principles can be applied to enhance machine efficiency and structural design. Our project drew inspiration from observing the swimming technique of freestyle swimmers, and we aimed to create our own propulsion system based on these observations. I took the lead in the research and development of the initial prototype that could recreate the propelling force of the swimmer with a mechanical design. This involved incorporating 3D printed 4-bar linkages, 3D printed pin joints, and a silicone-molded flutter kick fin to simulate the swimming motion of freestyle swimmers. Subsequently, we enhanced the

initial prototype by utilizing HDPE for increased robustness and integrating pre-existing scuba diving fins that were optimized in shape and material. In the end, our propulsion system proved to be more efficient, produced lower noise, and was more marine-life-friendly compared to traditional models.

In the fall of 2022, when I began my master's degree at Columbia University, my developing interest in biomechanics drew me to the research being conducted in Dr. Ateshian's lab. Consequently, I became a part of the Musculoskeletal Biomechanics Laboratory (MBL) under his guidance, serving as a graduate research assistant.

Within the MBL, I primarily immersed myself in a research project focused on the propagation of wear in human articular cartilage. This research aims to investigate the intricate mechanisms governing the wear and tear of human articular cartilage during daily living, with a specific focus on delamination wear due to fatigue failure. During my lab hours, I acquired various valuable skills, including conducting mechanical and frictional tests on articular cartilage and analyzing both qualitative and quantitative methods of assessment to discern potential sample damage.

During my initial two semesters, spanning the fall of 2022 and the spring of 2023, my primary focus revolved around honing a multitude of skills. This encompassed acquiring practices in dissecting human and bovine tibiae and femora, and familiarizing with the utilization of Polarized Light Microscopy (PLM) to observe and assess the degree of tissue damage in articular cartilage following frictional tests. Furthermore, I became proficient in employing Fuji film and ImageJ software to precisely evaluate initial and final contact areas between a mechanical

pendulum and cartilage, thereby facilitating the accurate quantification of contact mechanics and frictional properties.

Subsequently, in the summer of 2023, I undertook the role of a student research fellow in MBL from June to August. During this period, I began to effectively apply the skill sets I had acquired, specifically in the collection of data for reciprocal sliding tests on the human articular cartilage. The skills I cultivated and the tests I conducted not only deepened my understanding of articular cartilage behavior but also broadened my perspective on the progression of osteoarthritis.

In addition to my research experiences, my academic record in both graduate and undergraduate coursework is excellent. During my undergraduate studies, I successfully completed all required coursework with a high GPA in three and a half years, despite the demanding course loads I undertook. I was eventually awarded Cum Laude at the end of my undergraduate studies. Furthermore, I have maintained a similarly high GPA throughout my master's level studies. These academic achievements underscore my ability to grasp complex concepts and my commitment to learning. It demonstrates my teachability and my genuine enthusiasm for acquiring knowledge.

As a mechanical engineering student, I have also been captivated by computational modeling. I am contemplating a hybrid approach for my PhD studies, which would integrate aspects of computational modeling with experimental work. With this vision in mind, I believe that Dr. Gerard Ateshian's lab is my ultimate choice. Dr. Ateshian's involvement in FEBio-related

research aligns perfectly with my aspirations, and I am eager to continue learning under his mentorship. Thus, I am excited to apply to the Mechanical Engineering PhD program.

Throughout this PhD journey, my essential goal is to continue learning and growing as a research scientist. I aspire to acquire the skills, knowledge, and expertise necessary to lead independent research endeavors that yield significant findings. Since my prior experiences have been instrumental in shaping my career aspirations within the field of musculoskeletal soft tissue biomechanics and orthopedics, venturing into the industry as a Research and Development (R&D) engineer is my envisioned path upon completing the PhD program. This phase will offer me invaluable practical experience and insight into cutting-edge developments in the field. As I further evolve in my career, my ultimate objective is to establish a startup company focused on creating medical devices targeted at addressing musculoskeletal diseases, such as osteoarthritis and osteoporosis. The intent is to make a tangible impact on improving the quality of life for individuals afflicted by these conditions. Ultimately, I am driven by the desire to contribute to advancements in human health, making a meaningful and lasting difference in the field of musculoskeletal biomechanics and orthopedics.