Career Goals:

Fundamental to my passion for engineering is the core belief that intelligent machines have a tremendous capacity to elevate the lives of human beings. I have made it a point in my life to pursue a technical skillset, unlocking my abilities to design and create devices that will make a difference in the world. The primary goal of my engineering career is to advance the intelligence and useful capacity of machinery, emphasizing robotic systems and controls. I will accomplish this goal by strengthening myself as a researcher, an inventor, and a cross-disciplinary leader. Through these roles I will set out to solve the difficult challenges that align with my strengths and motivations, leading teams of engineers and researchers to create machines that will improve humanity. I intend to start a company specializing in robotic control for advanced applications after completing my Ph.D.

Graduate School Impact:

Graduate studies will enhance my research abilities, enabling me to incorporate scientific research effectively while creating solutions to critical problems in machine design and control. The ability to perform effective research and make contributions in my field is crucial, enabling others to build on my progress, but more important is the opportunity to interact with my peers. The relationships I form in graduate school will provide a basis for forming and leading teams of engineers and researchers in the future. To become an effective leader, I will learn how to bridge the differences between disciplines and build teams that can solve specific problems. Robotic solutions, which often involve mechanical, electrical, and software components, will especially benefit from this cross-disciplinary approach.

I expect my graduate studies to enhance my creative capacity as an engineer. I will devote my time to understanding the most important challenges in robotics, while exposing myself to a broad range of interests. Ultimately, having the right combination of knowledge and exposure to new ideas and problems will be the key to making my graduate school experience as impactful as possible.

Graduate School Contributions:

My proposed research aims to pioneer new methods for adapting robots to changing internal conditions. Executing this research plan will require maturity as a researcher, performing the due diligence to fully evaluate this control scheme compared with other methods. This will require a rigorous testing plan, and will necessitate collaboration with other researchers in the field to ensure that benchmark implementation and test cases are correct. I will need to demonstrate ingenuity as I design the new control algorithm and solve issues that arise.

This research has the potential to have a huge impact on control theory, especially in the field of bipedal robots. The most exciting aspect of the algorithm for me is the potential to unlock the capabilities of bipedal robots in the real world. Increasing the intelligent control of these robots would be a great opportunity and honor.

Motivation for Graduate Studies:

I grew up as a witness to a century worth of farming technology. Roaming my backyard, I scaled the decaying remnants of horse-drawn plows and harvesters once used to operate the farm of my grandfather’s childhood. It used to take a month to plant or harvest a half square mile of land, with two teams of horses working in shifts. The John Deere harvester parked across from this machine graveyard can now harvest four square miles in three weeks. The annual output of
grain produced by my family using modern equipment is enough to feed a town of two thousand people every year.

The capacity for machines to assist humans is enormous. Witnessing this capacity inspired me to pursue a career in machine design. More than just seeing, technology impacted my life by amplifying my labor capacity on the farm. Experiencing this power first-hand sparked my imagination and helped me to see the impact I could have on the world.

Experiences in Preparation for Research:

**ASME Energy**

As a freshman I was eager to develop as an inventor while studying at BYU. I joined ASME Energy, a club developing an automatic waste sorter. Throughout the academic year I worked with our six-person team to develop a solution for sorting containers made of glass, plastic, aluminum and iron. Due to my contributions in the design and programming of the machine, I travelled with our team leader to compete at the ASME Student Professional Development Conference (SPDC). Our machine placed third, but what was truly exciting was my exposure to graduate students and researchers from across the country, sparking my interest in joining a research group and sharing my knowledge with others.

**BYU CAD Lab**

As a sophomore, I joined the BYU CAD Lab, an NSF Center for E-Design site aiming to enhance the design tools used by Mechanical Engineers. The software plugin we were developing created a multi-user experience in a CAD program, allowing collaboration and teamwork within a design environment. While effective in theory, the plugin impacted performance and actually slowed down design work, invalidating thousands of hours of research and development. I decided to tackle the problem in collaboration with another researcher, and we spent many late nights attempting different approaches. We devised a way to embed the plugin information as generic metadata within the part file, decreasing loading times from 7 minutes to 5 seconds in one instance. We patented our methodology, with final utility patents awarded in the US and Europe, and published our findings in the 2014 Computer Aided Design & Applications (CAD&A) Journal. This period of intense inventiveness and collaboration was exciting and rewarding. We both acted as team leads over sets of four other researchers for the coming months, implementing other improvements and finalizing the new loading architecture.

**Sisu Devices**

I began an extended internship at Sisu Devices in Austin, Texas after undergoing a foot surgery that prevented my return to school for my junior year. Establishing myself early on in a small but growing company, I was able to lead the programming and development efforts for several six-axis robotics projects. These projects required fast, responsive control systems beyond the capabilities of the software provided with the robots. In one project, a robot moved a knife through a line scanner, capturing the three dimensional profile of the blade. In addition to generating a sharpening profile for moving the knife along a set of grinding stones, a feedback loop centered the knife on the stones and applied a constant amount of sharpening force. The final result was a knife sharpening system that was safer, faster, and more effective than a human operator. By mentoring a fellow engineer in the company, I was successful in completing the goals of the project while introducing him to the programming methods needed for developing advanced robotics applications.

I developed a framework for generating smooth robotic motion in order to obtain smooth robot control. Our applications required fast responses from heavy industrial robots, with
repeatable, deterministic behavior. Typical motion profiles for heavy robots rely on an s-curve solution, completing the current motion before proceeding to the next. To deal with this limitation, I developed an s-curve solution that accepted initial velocity and acceleration conditions, allowing new motion profiles to be generated and applied before completing previous motions. Redirecting robot motions on the fly increased the speed of response capable by heavy robots, and the closed-form kinematic solution for the motion profile ensured deterministic control of the robot. I filed a provisional patent on this technique, and standardized the framework across all of our robotics projects.

**Intellectual Merit:**
I continued my work at Sisu Devices on a part-time basis while I attended the University of Texas at Austin to finish my undergraduate education. After considering potential research positions, I determined that my development as an engineer would be best served by advancing my knowledge in robotics and continuing my research in novel control systems for six-axis robots. During my final years of undergraduate education, I have focused my energy on learning how to model and design control systems effectively. With my research experience in both industry and academic settings, I am well-prepared to pursue new challenges in graduate school, where I will be able to focus my energy and time on solving problems that will further the situation of mankind and enhance our nation.

**Broader Impacts:**
Beyond my contributions as an engineer, there is also a need to give back to society in other ways. I spent two years as a full-time volunteer in Los Angeles, California between my freshman and sophomore years. My experiences while reaching out to low-income groups in California highlighted the potential for STEM education to improve and lift the lives of children in difficult circumstances. Having started the path towards a STEM degree myself, I often shared my excitement for science and engineering with youth I encountered during this time.

While working at Sisu Devices, I was able to lead the programming and development work for Robo-Knot, a robotic knot-tying machine. This was a project for the Boy Scouts of America (BSA) designed to generate interest in STEM and scouting and leave a lasting impression on future engineers. Teaching the two six-axis robots to tie five different knots was tricky, but the real challenge was allowing the children to control the robots unsupervised while avoiding damage to the machine.

The machine featured a sensor for detecting and tracking hand input. By feeding hand information into a rigid-body simulation of the robots, the robot motion was tested virtually, preventing collisions and ensuring safety. This mode was especially exciting for the children, allowing them to stack cups, crush foam, and manipulate rope remotely. In addition to showcasing the robots for local scout troops, I delivered the machine to the BSA Discovery Outpost, a recruiting store located in Chicago. For a week I interacted with customers and youth in the mall, sharing my experiences with engineering and generating excitement for robotics.

Graduate school will further enable me to advocate for STEM education and increase my impact on society. My goal is to become a world class researcher, inventor and leader, but I recognize that oftentimes individual interactions make the most impact in the world. I look forward to an exciting career ahead, and I know that whether I’m leading a team of researchers or simply mentoring a future engineer, I will be making a positive impact in the world.