I love asking questions. My whole life, I have not stopped wondering about things. When I was young I asked questions like: Why is the sky blue? How do fish breathe? What does the dirt taste like? Some of my questions I could not yet answer, but for some of them, to the dismay of my parents, I could discover the answers myself. Eventually the questions got a little bit more sophisticated and a lot harder to answer by myself. How does long division work? So what's this thing called recursion? What actually is the Internet? I never felt satisfied to just be told a definition or an answer, I had to understand WHY things were true. It's all well and good to know how to use a Java ArrayList, but for me, I need to understand how the data structure actually works. Through my undergraduate coursework in computer science, I have developed a passion for striving to design, create, and understand complex systems. In truth, I cannot imagine a future for myself where I do not ask questions and pursue their answers. Thus, I would like to pursue a career in research, likely in an academic setting. For this reason, I wish to pursue a PhD in Computer Science at Vanderbilt University.

My undergraduate coursework has helped me prepare for graduate work in computer science. It has both taught me domain knowledge as well as helped me discover my interests and thus narrowed my focus. Additionally, my grades demonstrate that I am capable of succeeding at a high level in academics. At St. Lawrence University, I have completed 15 computer science classes so far, achieving a 4.0 GPA in all of them, with 2 more that I plan to take. These courses have ranged across a wide variety of sub domains. I have taken courses in theory, machine learning, cyber security, databases and more. I have completed large software development projects such as implementing an object oriented programming language interpreter in my Programming Languages class. Although I greatly enjoyed theory classes, I wish to pursue a more directly applied discipline. To me, the most interesting classes were those that dealt with hardware, networking, and cyber security. Although I have not taken a dedicated embedded systems class, I have been exposed in some ways to the subject through my computer organization class, as well as independent projects and research. Thus, cyber physical systems seem to check all of the boxes for me. It is very applied and would also allow me to exercise my interests in cyber security, networking, and theory.

I have also completed several independent coding projects as part of my classes. In my Game Development class, I created a 2D platformer game in Unity. In my Cyber Security seminar, I (along with two other students) asked the question: How do hackers control groups of computers at the same time? To answer our question, we wrote a bot-net command and control server as well as the client code that gets uploaded to bots. My partners and I presented this work at the St. Lawrence University Festival of Science. In my Graph Theory class, I asked the question: How can I represent individual drawings of graphs? I wrote software that allows users to define and manipulate graphs on screen as well as to run a graph algorithm I wrote over the defined graph representation to test if it is plane. I was given the opportunity to present this project at the Hudson River Undergraduate Mathematics Conference in the form of a talk titled "Onscreen Representations of Graphs and Testing if They Are Plane." These projects instilled in me a love of teaching things to myself. They forced me to discover resources that I could use to learn skills that helped me accomplish my end goals. This process is something that I have fallen in love with and is something I am excited to continue in graduate work.

Further, I have been conducting independent research with a faculty mentor. For the last two years, I have worked on a research project to add support for hardware redundancy to open source autonomous vehicle control software. Software vulnerabilities have been documented in autonomous vehicle control systems and have been exploited by hackers to jeopardize autonomous missions. Hardware and software issues have caused critical failures in autonomous vehicle systems that have both endangered the hardware as well as human life. These kinds of failures can be catastrophic in high value use cases such as search and rescue and disaster relief. I observed that redundant computers have been used to solve this problem in larger commercial systems and asked the question: How can we leverage redundant

hardware to add resiliency in smaller autonomous vehicles? My work specifically focuses on allowing the vehicle's control software to initialize while it is in motion. This is important to allow the primary controller to be stopped, patched, and restarted in the case of a failure. Thus, we allow a backup, secondary computer to control the vehicle while we restart the primary controller. Current software is rarely able to initialize fully while the vehicle is in motion because the vehicle needs to be stationary to have accurate initial readings. Our key insight is that transplanting information about the state of the vehicle from the running computer to the initializing computer, in order to skip sensor initialization, makes it possible to initialize while the vehicle is in motion.

I started working in a simulation environment where I learned the use of the software to control an autonomous vehicle through a mission. I also analyzed the source code and designed a set of experiments that we ran in the simulation. These included modifying the physics simulation to have the vehicle start in motion prior to initialization. I next developed a simple approach to data transplantation that only considered one sensor. However we quickly discovered that this was not enough. Through readings and further code analysis, I developed a technique to transplant data in and out of the mathematical and statistical model that handles the vehicle state. After validating this approach in simulation, I ported this code to work on actual autonomous vehicle hardware. I conducted many controlled experiments that measured the effectiveness of this method. I collected data related to the initialization times of the controllers with different amounts of data transplantation while stationary, rotated, and in motion.

This semester, I wrote a research paper with my advisor and a collaborator at another university, which has been submitted to the International Conference on Dependable Systems and Networks for 2023 for peer review. I was primarily responsible for the Introduction section, as well as the first drafts of the related works, methodology, and results sections. Additionally, I created figures to help demonstrate points within the paper and condensed the raw data into tables for the results section.

Another way I have sought to answer questions is through answering the questions of others. Since the fall of my sophomore year I have worked as a student mentor at the Peterson Quantitative Resource Center which is a center run by the Mathematics, Computer Science and Statistics Department to provide students with help in quantitative classes. These classes range from calculus and linear algebra to introductory computer science and data structures and many others. During tutoring sessions, I guide the mentees to a deeper understanding of the course material. I work with them to build a strong mental framework through which they can explore the concepts and create problem solving strategies that they can apply. I have assisted students with debugging their code through careful analysis and working through examples on a whiteboard. Additionally, for three years, I have helped create and present a LaTex workshop for Math and Computer Science students. I also have served as a Teaching Assistant since the fall of my junior year. I have TA'd both Intro to Computer Science as well as Data Structures. For the Intro class, I worked in the classroom to answer questions and solve problems as they came up in order to assist the professor. For Data Structures, I graded coding assignments and hosted office hours, both alone and with the professor, for students to come to and receive help and support with their projects. When grading, I worked through students' implementations of complex data structures and, without being able to run or test the code, was tasked with determining the validity of a given implementation. These experiences have helped me build strong communication skills around quantitative subjects and have strengthened my collaborative thinking and problem solving. Additionally, having the chance to assess and teach subjects that I have already taken has made the foundations of my understanding of more complex topics more sound.

Going forward, my research interests primarily lie in embedded systems. I am fascinated with what computer systems can do when interfacing with the real world. For example, how might autonomous vehicle technology be used to map coral reef bleaching? I wish to use

embedded electronics to accomplish goals that make a difference. Additionally, I am interested in cyber security and ensuring the resiliency of systems to cyber attacks. This is why I am particularly interested in Dr. Kevin Leach's work on debugging transparency while remaining open to other possible research experiences. I am incredibly excited at the prospect of working in a collaborative environment to pursue my research interests. My past exemplary coursework, teaching, and research (including a peer reviewed submission) make me confident that I can make a positive contribution to the Department of Computer Science as a graduate student.