I am excited to contribute to research in **programming languages, compilers, and verification systems**—fields that inspire me with their combination of theory, design, and practical application. My interdisciplinary academic background, shaped by hands-on exploratory projects, has prepared me to tackle fundamental challenges in these areas. At Penn Engineering, I see the ideal environment to expand my expertise through world-class faculty mentorship and an interdisciplinary, collaborative community.

During my undergraduate studies, I pursued coursework spanning computer science, electrical engineering, and physics, which allowed me to approach problems from different perspectives. Courses like **Programming Language Design (CS 422)** and **Compiler Construction (CS 426)** sparked my interest in programming languages: I implemented languages across paradigms using the **K framework** and built a compiler for a subset of COOL. In **Operating Systems (CS 423)**, I explored systems programming by developing Linux kernel modules, further solidifying my understanding of systems-level design. Projects like reconstructing the **Nintendo NES console on FPGA** and building a **mini kernel** for the x86 architecture pushed me to connect theory with hardware and systems implementation.

Motivated by these foundations, I pursued exploratory projects that deepened my research interests. Frustrated by LaTeX's cumbersome macros and limited flexibility when typesetting complex expressions, I began designing a **domain-specific language (DSL)** to improve readability and expandability. Inspired by **TeX's glue-box model**, I explored ways to modularize typesetting, introducing **Lisp-like user-defined syntax** for frequent constructs such as big-step semantics and ODE formulas. Prototyping an **intermediate representation (IR)** capable of rendering OpenType outputs allowed me to bridge high-level design with graphical rendering. Though still preliminary, this project taught me about balancing **expressiveness and usability**—a challenge that fascinates me in language design.

Similarly, working with TypeScript in web development highlighted challenges with its subtyping system. While powerful, its lack of advanced type operations often required convoluted workarounds, or as developers call it, "type gymnastics." To address this, I proposed a **predicate-based type system** that evaluates constraints at compile-time using metadata-driven predicate functions. This approach enhances flexibility, enabling more robust and expressive type definitions while maintaining consistency across imperative paradigms. These experiences taught me to **use type systems as tools** to refine programming languages, ensuring they align with both theoretical principles and practical needs.

Beyond these major projects, smaller explorations also enriched my technical perspective. I developed an **AI-based interactive storyteller** that generates story continuations based on user prompts and built a **mini kernel** for the x86 architecture, deepening my understanding of systems programming. Together, these

projects strengthened my ability to connect **high-level concepts with low-level implementation**, an essential skill for impactful systems research.

Penn Engineering's graduate program aligns perfectly with my research aspirations. I am particularly drawn to **Professor Benjamin Pierce's** work on type systems and formal verification, which resonates with my interest in designing augmented type systems to ensure correctness in software. His contributions to the **Unison** project inspire me to explore ways we can bridge type theory with robust, practical tools. Similarly, **Professor Stephanie Weirich's** research on **dependent type systems** and her contributions to GHC Haskell development align with my aspiration to create programming languages that are scalable, safe, and verifiable.

In addition, **Professor Mayur Naik's** work on program analysis and testing aligns with my goals of verifying large-scale systems to ensure reliability across diverse contexts. **Professor Steve Zdancewic's** contributions to secure programming languages and **Professor Rajeev Alur's** research on formal methods also inspire me to bridge the theoretical foundations of formal verification with practical concerns in compiler design and systems programming. I am confident that Penn's strong programming languages and systems research groups will allow me to pursue questions related to **universal compiler generators**, **meta-languages**, and tools that simplify language creation while preserving performance.

Beyond academics, I am equally excited about contributing to Penn's vibrant student community. As a designer of **autograders** for an algorithms course and a lab assistant in the ECE department, I honed my mentorship and collaboration skills. Whether it involved refining tools to improve student learning or adapting explanations to individual problem-solving styles, I learned how to build inclusive environments that enable peers to grow. At Penn, I hope to continue this work as a **teaching assistant**, helping others explore programming languages and systems. I also aspire to organize workshops and collaborative study groups that foster intellectual exchange and mentorship among peers.

Penn Engineering's rigorous program, emphasis on interdisciplinary collaboration, and exceptional faculty provide the perfect setting for me to advance my research skills and explore the questions that fascinate me. After completing my graduate studies, I aim to design tools and frameworks that improve **software correctness, usability, and performance**. I am particularly interested in developing **meta-languages** capable of generating languages based on their semantics—a pursuit that could simplify compiler development while ensuring verifiable behavior. I believe Penn's research environment will equip me with the tools and perspective to make meaningful contributions to programming languages and systems research.

With my background in **programming languages, compilers, and systems**, coupled with a strong sense of curiosity and initiative, I am confident that I will thrive as a graduate student at Penn. I look forward to contributing to its research community and growing as a researcher committed to advancing the state of the art.