

Statement of Purpose

When I began my career as an undergraduate at MIT, I had little idea of where I was heading. I decided to join the departments of aerospace and mathematics due to a long-standing interest in the former and my strength in the latter. My advisor in the aerospace department, Professor David Darmofal, introduced me to Computational Fluid Dynamics (CFD) during the summer after my freshman year by offering me a job as an undergraduate researcher. I jumped on the position, seeing it as a wonderful opportunity to combine my experiences from both departments.

Professor Darmofal originally offered me a position due to my coursework in quasilinear PDEs and numerical analysis, which were all far beyond the standard freshman curriculum. I have since tried to enroll in classes that I felt would best prepare me for a future in graduate school by studying topics in fluid mechanics, aerodynamics, and numerical methods. Having just completed graduate courses in “Numeric Methods in PDEs” and “Numerical Linear Algebra” with high standing, I believe that my exceptionally solid background leaves me well prepared to make useful contributions to Stanford’s graduate program.

Through my coursework and summer employment, I have also accumulated valuable research experience in CFD and related topics. I spent the summer after my freshman year implementing a serial version of GMRES with preconditioning in a higher order, Discontinuous Galerkin, finite element framework under the supervision of Professor Darmofal. I worked alongside a team of roughly 10 graduate students and faculty. At the time, the CFD code lacked a fast, robust iterative solver for linear systems. The GMRES implementation proved to be 200% to 400% faster than other options while maintaining robustness. Later in my junior year, I researched and wrote on the stability of Poiseuille flow under small perturbations to see why turbulent transition is predicted at $Re = 5772$ but observed at $Re \approx 1000$. The work was fundamentally an investigation of transient growth in non-normal operators—specifically the Orr-Sommerfeld Operator. I implemented a differential equation solver based on Pseudospectral Methods, replicating numerous existing results and observing how earlier, eigenvalue-based asymptotic analysis does not apply in the case of non-normal operators. Lastly, during the past summer, I returned to Darmofal’s CFD group, this time working closely with another undergraduate. We investigated the issues experienced by researchers when conducting sensitivity analysis of nonlinear problems exhibit long-term, oscillatory behavior. If one chooses the linearization naively (e.g. using the last state of the nonlinear iterations), the linear system is highly likely to be unstable. Working closely with Professor Darmofal, we suggested an alternative linearization with time-varying coefficients on a model problem, with success in the primal and adjoint cases. We will be submitting a paper for publication soon.

Moving toward graduate school, I am interested in continuing my study of CFD and also the broader field of numerical analysis. The ICME is home to several faculty with research interests that match closely with my own. Professor Juan Alonso comes to mind; some aerospace simulations attempt to model the coupling between aerodynamics, solid mechanics, and other factors affecting an aircraft in flight. Often, such codes are strong in one area (e.g. aerodynamics) at the cost of using rudimentary, low-fidelity models for the other effects (e.g. aeroelasticity). I would be very interested in working with Professor Alonso on developing multidisciplinary design tools that are not ad-hoc but instead both accurate and fast. Professor Sanjiva Lele has also caught my attention with his work on accurate prediction of flow instabilities. Although I have only scratched the surface of this topic with my study of non-normal operators, I would enjoy the opportunity to work on flow transition in-depth. Professor Lele’s research is working on answering many of the questions that I have come across, and it would be exciting to conduct research toward a better understanding of flow transition phenomena.

Unsurprisingly, my ultimate academic goal is to obtain a Ph.D. A Ph.D. from Stanford would leave me well prepared for any postgraduate endeavors, be they academic or corporate. Although the latter is certainly a possibility, I am currently more interested in staying in academia. I have greatly enjoyed my research experiences so far, and the university atmosphere is unparalleled in industry.

My focus on building strong fundamentals in math and fluids as an undergraduate has equipped me with a unique set of abilities to offer Stanford's ICME graduate program. I have tried to ensure that I would be well prepared to pursue further, advanced work in the Ph.D. program studying computational methods, particularly in the domain of fluid mechanics.