As a high school student and hopeful future cosmologist, I was intrigued by the still-unanswered question: what is the shape of the universe? This fascination was an important prompt leading to a degree in mathematics and physics, and continues to motivate me today as an aspiring mathematician.

At the completion of each of my undergraduate years at the University of Auckland, I was awarded a Summer Research Scholarship. Such scholarships supported student investigations of suggested research topics and acted as a conduit from the classroom to research experience. My primary goal throughout these projects was to discover something previously unknown to science, but I also had the underlying objectives of determining whether I was better suited to research in mathematics or physics, and whether or not I was suited to research at all.

After my second year as an undergraduate, I was awarded a scholarship to research continuum theory - the study of connected compact metric spaces. My supervisor for this project, Dr. Sina Greenwood, simply instructed me to explore the world of generalised inverse limits (GILs) and find a suitable question to work on myself. This caused me some anxiety, as I knew very little topology at the time and had expected to receive some guidance on what problem to work on. However, after a month of learning relevant concepts and reading a number of papers on GILs, I discovered an unanswered question that I was genuinely interested in solving. Namely, what are the necessary and sufficient conditions for a generalised inverse limit to be an arc? In the subsequent months I made non-trivial headway in each direction, creating my own conjectures and proving or disproving them.

During the course of this project, I sometimes felt that my progress was impeded by a block wall. Initially, at such times, I spent hours trying to break through the wall directly. For example, I was convinced that any subcontinuum of a one dimensional locally path connected plane continuum must also be locally path connected, and therefore spent many days trying to find a direct proof without varying my approach. Eventually I realised that my conjecture was false, as the Sierpinski carpet provides a counter-example. Through such experiences, I learned how to vary my approach towards problems and deal with obstacles that appear in my research. Most importantly, I learned that I enjoyed research and can succeed in a research environment.

The following summer I was awarded a scholarship to study the drop-impact dynamics of ferrofluid droplets through magnetic fields. Although this project was entirely experimental, I often found myself trying to understand the more mathematical aspects of the experiments. For example, when a ferrofluid droplet comes to rest on a horizontal surface with a vertical magnetic field, so-called Rosensweig in-stabilities form throughout the droplet. I was fascinated by the interplay between surface tension and other forces in determining the equilibrium state of the system, and wanted to uncover the underlying mathematics. At about this time, I began to realise that while the problems that interest me most are physical in nature, rather than resorting to experimentation or simulations, I am inclined to look for mathematical explanations.

It was during this time that I had a conversation with Professor Rod Gover of the University of Auckland Department of Mathematics. By now I had developed an interest in geometry, and having learned that he was a geometer, was curious about the work he was doing. He explained that he works on mathematics that is motivated by physics, describing conformal geometry, projective geometry, and Klein geometries. When he made an aside that he wished to understand mass through geometry, I knew that I wanted him as my supervisor for my Bachelor of Science (Honours) research project. Up to this point, I had believed that my interests in mathematics and physics could not be fused, but Professor Gover's work was a perfect blend of my interests: I could create maths and write proofs so as to better understand the world around us.

Over the course of 2018 I worked on my Bachelor of Science (Honours) project, titled "Asymptotic curvature of hypersurfaces in Minkowski space", supervised by Professor Gover. I was tasked with determining whether or not constant mean curvature hypersurfaces of Minkowski space, and more generally asymptotically flat spacetimes, are themselves asymptotically hyperbolic. Using conformal tractor calculus I showed that the above is true for surfaces that conformally compactify correctly, and that the asymptotic limit of the trace free part of the second fundamental form is an obstruction to compactification. I am currently preparing the results of this research for publication (with Professor Gover).

My long term goal is to become a researcher who contributes to geometry and mathematical physics, my short term goal being to learn a wide range of mathematics that will help me to become more effective in the long term. Earlier in 2018 I spoke to Professor Rafe Mazzeo, who jokingly said that "the math department at Stanford has too many student seminars". Those words stuck with me, and are one of the primary reasons that I believe Stanford University is the best place for me to pursue graduate study.

At the University of Auckland in 2017 I ran the mathematics seminar club, an informal organisation of undergraduate and postgraduate students who met every week and presented diverse lectures. For example, seminar topics included tropical geometry, p-adic analysis, dimension theory, morse theory, and computational graph theory. In the second half of 2018 I helped to start up a homological algebra reading group (based largely on An Introduction to Homological Algebra by C. Weibel). I have subsequently presented to the group four times, each being an hour long lecture. Most recently, I discussed Cartan-Eilenberg resolutions and the Grothendieck spectral sequence.

At Stanford University I will continue to contribute to extracurricular mathematics groups to widen my knowledge of mathematics, as well as to teach mathematics to other students. In the intervening months, most of my time will be spent working as a research assistant at the Auckland Bioengineering Institute under Distinguished Professor Peter Hunter. I am applying graph-theoretic concepts to more effectively model Lithium-ion batteries, the bottleneck for further improving technologies including electric cars and smartphones. However, I will also start an algebraic geometry reading group, and continue to self-study symplectic geometry and mapping class groups.

At Stanford University I am interested in working with Professor Mazzeo, a number of whose publications dealing with asymptotically hyperbolic manifolds I read whilst doing my Honours project. I have found his research in geometry, using a wide range of mathematics, generally with an analysis flavour, to be most helpful in my own mathematical development. I am also interested to learn more about curvature flow and symplectic geometry, and Professor Brian White and Professor Eleny Ionel appear to be doing great work in these areas.

Through my research and study experiences, I present myself as a motivated student who is well prepared for graduate study. I strongly believe that my interest in physics will offer a perspective of mathematics that will benefit my peers, and that Stanford University offers me the best chance of being a productive mathematics researcher.