My Interest in Geometry and General Relativity

An interest in physics, seeded by fascination for exploring the inner workings of nature, led me to opt for a Physics major at IIT Kanpur. When I was first introduced about the concept of fields and potentials during high school, it was really a transformative experience for me, that things can talk to each other without even touching with the help of force fields. My high school physics teacher used to praise a book by the name of "Introduction to Electrodynamics". In an avalanche of curiosity, I bought that book, which turned out to be one of the best things in my life, and started to read the first chapter which was all about vector fields. I was drowned into the beauty of mathematics describing those fields.

When my freshmen year started, I was re-introduced about Newton's Laws after high school. I celebrated the success of those laws, after all they explained uncountable phenomena that occur everyday in nature. But then I looked deeper and asked myself "What is a Force? Or how does one measure a force?". This question remained inside the active corners of my mind. During that time, I was also working on vector fields. I did solve some special cases of vector integrals on loops, surfaces and volumes. I went on to generalize those in higher dimensions. But soon I realized that there were some problems among which the major one was that **Area vector** can't be defined as a vector in 4 or more dimensions. I tried many attempts to solve that. During one of my lectures on Newtonian Mechanics, the professor introduced us with an ancient problem by the name **Brachistochrone problem**. I tried very hard solving that. Soon a new course Electrodynamics started and I found the description of magnetic field a little unsatisfactory. Magnetic fields are described as pseudo vectors not as some real objects. Pseudo vectors break some symmetries. So I added one more task which was to construct a real mathematical object which can describe magnetism accurately. New problems were being added to my list and few of them were solved.

After struggling through months in the quest of those problems, I realized that the problem of area vector and magnetic field are exactly the same and soon found their solution. That real object to describe a magnetic field is a tensor and to describe area in higher dimensions we require a tensor. Generalizing area tensor led to new problems of generalizing volume in higher dimensions. Luckily, the its answer came when I was introduced the idea of mathematical exchange asymmetry in Fermions in a Quantum Mechanics course and generalized those ideas not only for area or volume but for any dimensional element. I also developed some kinematics of continuum bodies and developed independently a theorem in fluid mechanics called as **Reynold's Transport Theorem,** which I used later to prove **Ampere's Circuital Law** for this newly developed

Magnetic Tensor. Using those same ideas, I got a huge storm of new ideas and realized that I can finally solve Brachistochrone problem and I did, which was the happiest day of my life. I soon generalized the solution of Brachistochrone problem and developed independently calculus of variations up to a basic level. All these ideas led me to think that "Everything is connected, if you look close enough." I did a satisfactory amount of mathematical research in many other but related ideas and generalized many theorems of vector calculus into tensor calculus and before all this I didn't know much about tensors. But because I needed some mathematical objects and tensors came up to the rescue, I appreciate tensors quite a lot. Discovering things by myself led me to highly appreciate each and everything that was included in my coursework or otherwise.

During my sophomore year, I did a course on Special theory of relativity which opened my mind even more. Then I read about Einstein's Equivalence Principle and I was shocked by the simplicity and elegance of the idea. The idea that gravity is not a force but manifestation of the curvature of 4 dimensional space-time is mind boggling for me and hugely influenced me. Suddenly, I found a good answer to the question I had long time ago about "Forces". But the answer led to some new questions too. In my current course-work I chose Mathematical Methods as one of my courses which includes tensor analysis which refined my ideas even more. My love towards Mathematics is increasing everyday, adding new problems to my list and trying to solve them.

Considering all this, I request you for a chance to work with you on a problem on general relativity, to be solved or understood, in summer 2018. This assignment would give me a chance to obtain a diversity in my approach towards research and also instill in me a structured and dedicated learning paradigm and help me transcend into a better researcher. To attain a prerequisite first level of apprehension, I have about 6 months before summer of 2018, in which I shall be studying about General Relativity with as much effort as I can and will try my best to work under Prof. Bhattacharya for general relativity. I am ready to stay in constant touch with you till summer, updating myself regularly of the advancements in the field and come prepared before the internship.

Hoping for a wonderful chance
Yaman Sanghavi