Over the last four years, I have developed from somebody who, though interested in physics, struggled with the subject and with math, to being relatively competitive for grad schools in the field. Looking back, I've identified the following themes that have been most significant in this development: (1) slowly developing a competency for physics and math, (2) working on physics and research in the context of a group and in a solitary context, and (3) learning the social aspects of physics research.

(1) Coming into college, I knew I was interested in physics and the sort of questions it allowed you to ask, but I had very little experience with and ability to solve physics problems. I had not considered myself as somebody interested in or capable of solving physics problems until much later in high school, when I realized that most of the philosophical questions I was interested in thinking about were in the court of physicists to at least reframe the questions in a more rigorous manner or possibly answer them. Because of this, I had not cared for physics or math classes until late into high school and therefore was very poor at solving problems in them since I hadn't yet developed the basic cognition of a physicist or a wealth of previous experience with solving problems to reference. In short, I was incompetent and inexperienced with physics and math during my freshman year relative to others at that stage. Throughout my freshman year and into the fall of my sophomore year, I took the *most* basic physics and math classes that developed the skills and frame of mind essential to moving on to studying the subjects in physics that had first drawn me to the field.

Taking Modern Physics in the spring of my sophomore year, I was finally in a physics class where the mundane problems of determining how far a ball would land after being launched from some angle had been replaced by thinking about what the hell a wave function is and learning to represent it mathematically. My sophomore year was also around the time that numbers and dull computation became a rare occurrence in homework problems for my math classes. During the summer between my sophomore and junior years, I began to notice that I had more ability for physics and math than I thought I had for the majority of my life. Coming back to school my junior year, I had an unfamiliar confidence in my ability and wanted to push myself intellectually harder than I ever had. During this time, I found a great joy for theoretical physics and began studying difficult subjects in my little free time during that semester, which was a skill I had begun developing when I first turned to physics and forced myself to relearn all the math I had forgotten or missed prior to that point. I have continued to pick up difficult topics in physics and math on my own, and believe that this is a desirable quality for anybody wishing to pursue a graduate education.

(2) Engaging in a variety of research projects has been the most distinctive mark of my development over the last three and a half years. In the work I have engaged in, I have learned a variety of technical skills and have carried this work out in a variety of environments. My first research experience in Dr. Crosby's lab was very aligned with my initial perception of how research in physics was carried out. Regardless of which of the many projects he organizes, each features the theme of having a relatively large group of students work simultaneously on the same experimental device where the collaboration between members of the group is physically apparent. When I began working with the gravitational waves group that Dr. Quashnock directed, the same structure of research was also found in this work, but it was

initially less clear to me that this is what was happening, since the collaboration was a bit more distanced between group members by the nature of the work and wasn't as obvious as physically building an experimental device with a team was. During my summer at LSU, though there was active collaboration between group members, each member was working on their own research project. I was thankfully working under the guidance of a graduate student who engaged in very similar research to my own, but who was not attempting to answer the same questions I was. Though I definitely pestered him with questions and my own problems more than he had anticipated, I had a great summer working with such a fun group of people and left the summer knowing that sort of collaboration was close to my ideal research environment.

When I came back to Carthage my junior year, I continued working with the gravitational waves group in the sort of research environment that I was used to, but I didn't put nearly as much effort into the work as I had previously. When my class load became slightly easier in the spring semester of my junior year, I began working on a theoretical research project with Dr. Anderson. This was the first time I was the only student working on a research project, and being able to meet and talk with Dr. Anderson for longer periods of time than I was used to working with research advisors made for an enjoyable experience. I enjoyed the independence of the work and felt that the amount of time Dr. Anderson and I met reflected the difficulty of the problem. When I went to Penn State for the summer between my junior and senior year, I was again working completely independently from any other undergraduate or graduate students, but this time I felt that the amount of time my mentor and I spent meeting did not reflect the difficulty of the work. Though I was able to get more work done than was expected, I spent the majority of the summer extremely frustrated; often having to entirely stop working midway through the day and attempt to pick myself back up after resetting for a few hours. I ended the summer with a good deal of pride in my work, knowing that though I was guided by my mentor, what I had made was *entirely* my own work. I didn't think the amount of frustration was justified, though, and knew that I could have gotten much more work done if I at least had a grad student to regularly talk to.

Looking back on my experiences in research environments over the last three and a half years, I have developed from somebody not having any experiences in such environments to somebody who has had a wide range of experiences, which has greatly informed the sort of research group I want to join during grad school.

3) An unexpected, and by far my favorite, personal development over my undergraduate career has been recognizing how important the social component of physics research is. Though I was attracted to physics for its ability to reframe philosophical questions in a more rigorous manner and possibly answer them, I also came into physics with the belief that most people involved with its research were near-robotic machines that created and transferred scientific knowledge in the most efficient format for communication between flesh motherboards, since these were the sort of characters who I found were interested in physics prior to coming to college and engaging in research for myself. Though it's not difficult to find examples fulfilling this stereotype, I have been pleasantly surprised to find entities closer to human than to machine in research labs and in university departments. Discovering the majority of physicists to display characteristics of humanity, I was again pleasantly surprised to find that a vital part of what it is to be human, face-to-face communication with others, was also to be found in physics research,

and is in fact crucial to the development of the field. I most vividly remember being taught this dependence of physics research on human interaction in the form of seminars, conferences, and even short conversations by Dr. Quashnock throughout my sophomore year. His attitude towards learning across a spectrum of physics for its own sake and his advice to "just show up" for events that may not even be of relevance to your own research interests have left a deep impression on my life. Hearing from his personal and historical anecdotes of the *all too human* controversies and quarrels found throughout the history of science, which have often been vital in the field's progress, throughout my undergraduate years has revealed to me the essential human nature in research and has given me the assurance of humanity's irreplaceable position in progress.

With this perspective on the human nature of how scientific knowledge is spread and developed, I have since attended all the conferences I could reasonably attend and taken great joy in participating in the irreplaceably human component of research. In fact, looking back on my undergraduate years, some of my most enjoyable and memorable experiences have been at conferences or meetings. This perspective on the nature of research in physics will doubtlessly be of great benefit to me if I'm to be accepted into a graduate program, and especially if I find myself working in a field that depends on big science and large collaborations, as was the case during my summer at LSU. As I close out my undergraduate years, I look forward to continuing to celebrate this fundamentally human nature of research which I am deeply grateful for having learned during the last three and a half years.