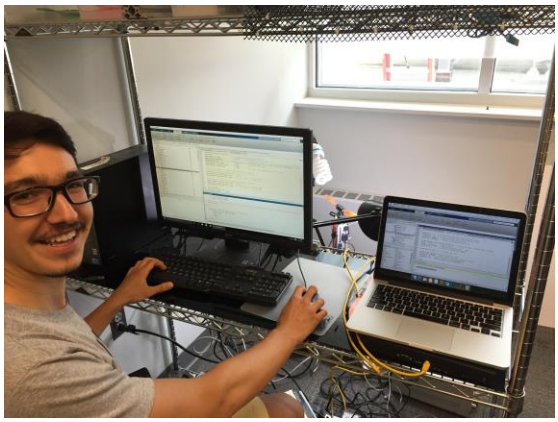

Frequency Response of Variable-Pitch Propellers
Brad Pettigrew (COL 2017)
Advisor: Mark Yim

This past summer I worked in the ModLab with Professor Mark Yim on his continuing research into propeller control. ModLab is a subgroup of the GRASP Robotics Laboratory in the Mechanical Engineering Department with a focus on modularity, integrated mechatronics and control, and innovative actuator design in robotics. The laboratory has several projects trying to make aerial robotics smaller or simpler. The propellers I was working with are intended to help make common quadrotors and other small flying vehicles more agile.

My research involved characterizing one's ability to control a propeller, or more technically the responsiveness of the mechanical system to input. In a typical propeller the two blades are ordinarily fixed at the same pitch and the thrust is controlled only by changing the blade speed. However, over the summer we expanded on previous work in which it was discovered that altering the pitch and speed at the same time, one can dramatically speed up the thrust response. One way this is measured is through a step response test: the propeller assembly is mounted to the top of a fixed structure with a thrust sensor on top; the propeller is spun to a reasonable operational speed and then signaled to speed up or slow down (hence, step) – the time the propeller takes to make this change is a quantifiable difference in responsiveness.

As a pure mathematics major, I found the experience immensely satisfying in terms of learning the physical interpretations of abstract mathematical machinery I had been working with for years: from using groups to represent kinematics of rigid bodies, to using systems of linear differential equations, to represent the aerodynamic and inertial behavior of the mechanical system. In addition to learning applications of the theoretical concepts I had already known, I learned the practical, hands-on skills necessary to rigorously test and implement this theory. By the end of the summer, I learned a bevy of new software tools such as MATLAB, Solidworks, and C++ for embedded code. Further, I gained access to a number of skills necessary to constructing my experiments such as manufacturing and circuit design. This isn't to say that I've become an expert in any one area, but rather that I've gained real-world exposure to a whole set of new and exciting areas. Nonetheless, it has profoundly inspired me, and I am committed to learning more by now submatriculating into the MEAM masters program.