Provost's Initiative on Undergraduate Research
Undergraduate Research Collaboration Award Application
Spring 2018 Awards

Name of Faculty Applicant: [redacted]

Do you have experience researching collaboratively with an undergraduate in the past? If so please list your past experiences. No, I have not.

Name of Proposed Student Applicant(s): [redacted]

Have you worked with this student before? [redacted]

Does this student have experience collaborating on faculty research? [redacted] has experience from [redacted] has not collaborated on faculty research.

Title of Proposal: System Identification Methods for a Hexacopter Unmanned Aerial System

Will you receive financial support from another source (university or external) for this project during the spring semester? No.

If so, what is the source of the funding?

I. Please provide a brief summary of the proposed research project; include any potential deliverables for the project.

The research project will be in the area of new methods in frequency domain system identification for development of dynamic models for small unmanned aerial systems. The students be learning advanced mathematical techniques such as applications of Fourier transforms and applying these techniques to develop new research that will help to understand the dynamic model properties of the hexacopter aircraft configuration. The potential deliverables are mathematical models that have been verified against flight data as being very accurate. The students will write this up in a report at the end of the semester. If all goes as I hope, this will lead into summer research [redacted]). The research will continue with more advanced topics into the summer and which will result in a submitted journal paper next year. This spring semester research will allow the students to do develop more advanced models during the summer because they will already have a semester of research complete before summer begins.

II. Describe why this project is appropriate for collaborating with a student researcher?

The methods used to create the hexacopter model are done by collecting flight data and fitting models to the data, which will result in a very accurate simulation model (if the research goes as expected). Student researchers can design the experiments to setup the aircraft for data collection and do benchtop tests to ensure that the data is correct before going to flight test. They will also collect the data needed (in flight test) to extract the models, they can analyze the data using

software tools learned in mechanical engineering classes. When combined with additional mathematics that the students will learn during our weekly meetings, they will be able to conduct quite novel research in the area of frequency domain system identification. The mathematics behind the techniques are just beyond what the students currently know, but within reach for the students to learn and apply in a semester. The applied aspect of the research lends itself well to undergraduate researchers, who will at the end of the semester be able to develop simple mathematical models of the hexacopter, which we will be able to compare to the flight data that was collected to assess their accuracy and develop conclusions. During the summer, they will work to collect more flight data and develop more advanced models of the hexacopters. This is meaningful work that is novel and I expect to publish the results in a peer-review technical journal, but still within reach and interest-level of the undergraduate student.

III. Please explain why you believe this student is the right student to conduct intensive research?
Most importantly, both students are excited about flight research and on working with the hexacopter. In terms of skills, the two students (are in the class Both students are excellent in understanding not only the numerical methods, but also in programming with Matlab – both the math and the programming are key foundations of this proposed research project. I believe that the combination of being excited about the project and having the skills needed to conduct the research will be a successful combination. They are both driven and motived students who want to really understand the class content and ask questions about what the engineering curriculum means in the big picture – characteristics that are critical for a researcher. Because this is an intensive research project I believe that two students paired together will prove more effective than a single student working alone.

IV. What are the specific roles and duties of the student with regard to this project? Stating the student will read and write or conduct research is insufficient. Please be specific with regard to the specific skills and tasks the student will be engaged in.
Students will be responsible for getting the research aircraft ready for conduct of experiments. This includes benchtop tests to:

1. Ensure that the aircraft is setup correctly for flight (it is a research platform that I built up, not a ready-to-fly drone).
2. That the sensors are working properly to collect the necessary data needed for the development of the dynamic models.

Students will be responsible for the analysis of the flight data that will follow the benchtop tests, to include:

1. Determining the quality of the data (using methods I will teach them in our weekly meetings and review of literature).
2. Applying frequency domain methods (Fourier Transform) and simple model fitting techniques to develop and verify simple but accurate simulation models.

Students will document their research, including a literature review, in a final report. A midterm report will also be due to ensure that they are making progress in documenting their work.

V. What knowledge and skills do you hope the student will get out of the project?

I hope students will learn how to use math and engineering to provide a new perspective about the behavior of mechanical systems, in this case a hexacopter drone. This skill is a key element in every mechanical engineering research project. I want them to learn how to solve problems on their own – to trouble shoot data and make sure it makes physical sense. I want them to learn how to pull together techniques learned in many different classes to an applied research setting. I hope they learn the skill of how to present their research clearly and concisely, and that they can articulate how their research fits into the bigger picture.

VI. Please outline a tentative work plan (week by week) for the semester that includes both the faculty member and student responsibilities.

Week	**Weekly Meeting Topics**	**Student Exercises to supplement research topics**	**Research Tasks**
Week 1 1/15	**Review Syllabus and Expectations. Introduction to System Identification**	**Use Google Scholar to find 2 research papers on system identification**	**Read the 2 research papers from google scholar. Start an annotated bibliography (which will be an appendix of the report)**
Week 2 1/22	**Discuss literature review with students. Review math: Solution of Linear Ordinary Differential Equations via Laplace**	**Solve differential equations using Laplace tables**	**Read online information about Ardupilot – write an overview to include in appendix of your report.**
Week 3 1/29	**Discussion w/ students of last week's research. Review: 1st and 2nd order system time responses, simple system ID techniques**	**Do some simple system identification, given time responses**	**Read online information about ground station and how to connect to Pixhawk. Write an overview to include in the appendix of your report.**
Week 4 2/5	**Discussion w/ students of last week's research. Frequency Responses: How to make Bode plots 2nd order**	**Draw simple 2nd order Bode plots. Use Matlab to check answer**	**Get Radio talking with Pixhawk. Use mission planner to setup hex configuration. Start to work toward getting motors spinning in correct directions (blades off).**
Week 5 2/12	**Discussion w/ students of last week's research. Frequency Responses: How to make more complex Bode plots.**	**Draw more complex Bode plots. Use Matlab to check answer**	**Continue work to get motors spinning in correct directions (blades off).**
Week 6 2/19	**Discussion w/ students of last week's research. Data**	**Matlab code for frequency sweep.**	**Collect desktop data and look at log files in Mission Planner. Output Log Files to Matlab in**

Bring Laptops	**collection for calculation of frequency responses: Frequency sweep**		**Mission Planner from your respective vehicles. Load in Matlab and make plots to ensure data makes sense. Write midterm report.**
Week 7 2/26 Bring Laptops	**Discussion w/ students of last week's research. How the parsing code works.**	**Begin editing parsing code for your application.**	**Work on midterm reports. Use code to get your data from Mission planner into format CIFER can read.**
Week 8 3/5	**Discussion w/ students of last week's research. FRESPID MODULE: FFTs and Windowing.**	**Choose window lengths for example data.**	**Work on Midterm Reports. Due at end of week.**
Spring Break	**Read 1-2 research papers and add to the annotated bibliography.**		
Week 9 3/19	**Discussion w/ students of last week's research. MISOSA MODULE: Multi-Input Processing**	**MISOSA for example data.**	**Continue editing parsing code. Add additional parameters to log file as needed for system identification to the ardupilot code. Test that it works.**
Week 10 3/26	**Discussion w/ students of last week's research. Transfer function modeling.**	**NAVFIT for example data.**	**Research PID gain settings for Hexacopter on Forums. Setup in Mission Planner. Prepare for flight test.**
Week 11 4/2	**Discussion w/ students of last week's research. Help with prep for flight test**	**Prep for flight test.**	**Flight Test Week 1. Start writing final report.**
Week 12 4/9	**Discussion w/ students of last week's research. Help with Prep for flight test.**	**Prep for flight test.**	**Flight Test Week 2. Analysis of Collected Data. Writing of final report.**
Week 13 4/16	**Discussion w/ students of last week's research. Data analysis trouble shooting and transfer function modeling**	**Review data analysis with** [redacted]	**Transfer function modeling and verification of dynamic model. Writing of Final Report.**
Week 14 4/23	**Discussion w/ students of last week's research.**	**Review final results with** [redacted]	**Final report due.**
Finals Week			