SYLLABUS

Fundamentals of Unmanned Air Vehicles (UAVs)

Theory, Practice and System Descriptions

Course Description

This course will cover the instruction in, and deployment of, key knowledge and skills associated with the characterization, operation, design, analysis and testing of unmanned air vehicles (UAVs). Primary focus will be given toward description of a UAV as a system. The course explores the essential underlying physics, configuration issues, system development, guidance, navigation, control, and sensors of UAV problems, including autopilot for stability, control and functions of path planning. The course material leads the student from basics and history of UAVs through fundamentals of aerodynamics, communication data links, payload capabilities, and state estimation using onboard sensors, to maneuvering through desired paths. To facilitate understanding, the intent is to augment traditional homework assignments with a simulation project utilizing a MATLAB modeling environment along with flight demonstrations and testing with remotely controlled (RC) model aircraft. Students develop understanding of a low-level autopilot code, a path-following routine, and plotting algorithms. Students will further be exposed to UAV controller development through flight testing of the RC aircraft. Students will observe involved with operation and programing of flight of small RC aircraft (e.g., quad-copters).

Periodic relevance to real-world examples of applied engineering based on the instructors 30+ years of experience within the area of aviation will be included.

Lecturer

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Office Hours: after class or by appointment

Credit hours

3

Textbook

- **Instructor developed hand out material**
- **Considering:**
  - **Small Unmanned Aircraft: Theory and Practice**
    by: Randal W. Beard & Timothy W. McLain

MATERIAL

Classroom

The primary material for this course will be the notes in presentation slide format. Each week will provide added slide sets for review. Periodically, the text book will be used for added details. The class lectures will cover material in a progressive manner building on previous topics. *Instructor will use classroom time to cover key material in the course and answer any questions about the assignments, lectures or reading.* Thus, it is critical for students to be sure to proactively be researching related literature associated with the material as it is being covered within the class. Lectures will be presented using Powerpoint/PDF while at times being subsidized through whiteboard-based real-time discussions. Lecture notes will be distributed via a series of pdf files prior to the presentations. Students are encouraged to review the information in the course material pre and post lectors.

SPECIFIC COURSE INFORMATION

This course is a complete and stand-alone subject that will provide an understanding of the fundamentals without having to take added courses.

Required Pre-requisites: Physics, Thermodynamics, Fluid Mechanics, Differential Equations, and basic knowledge of MATLAB.
Recommended Pre-requisite: None

SPECIFIC GOALS OF THE COURSE

Course intent is to provide key building blocks toward a broader robotics focus (all be it directed primarily toward UAV platforms). This course is aimed at students interested in development, testing and operational use of UAVs. The course will discuss fundamental of UAV autonomous/automated guidance, navigation and control. In addition, the course seeks to provide basic knowledge of the broader UAV system including sensors, data links, and payloads. While the course is not intended to establish expert knowledge in any of these disciplines a review of the fundamentals will enable the students to obtain sufficient knowledge and skill to address the holistic characterization. Students will be exposed to basic flight testing of a simple UAV system.

Specific sections of the course, listed below, will enable to student to understand and assess basics of UAV configurations, flight performance, and vehicle management and control characteristics.

Course sections:

1. Intro / What are UAVs / Why / How to us**e** them…
   with Example(s) of commercial and military uses/missions
2. Concepts & Design/Test Considerations
3. Navigation system
4. Communication link
5. Sensors / Payloads
6. Mid Term Exam
7. Flight Article Description & Preping
8. Flight Controller (PixHawk) & setup

9. Controller tuning (PID) & Test Planning
10. Flight Testing
11. Auto Flight tunning & planning
12. Flight Test
13. Brief/Present Testing Results
14. Final Exam

This class includes a brief review of applied analysis methods and modern approaches in UAV development and evaluation. Topics covered include analysis of aircraft motion; Learn how to identify the basic mode of the vehicle flight; Sensors/dynamics/control simulation; Analyze the control system; Classical methods and systems are discussed, with emphasis on the full UAV system and the key elements.

Furthermore, course content provides a description of the a set of key concepts and technologies underlying the development and operation of UAVs, and enables students to have an introductory-level background to enter this exciting and important area of practice.

Students will be involved with a hands-on introduction through the use of

- Two (or more if desired) Flight Test Articles
  - students will fly and evaluate RC aircraft flight articles
- Project
  - "Program", Assess and then fly instrumented, RC aircraft (Measure, Analyze, Evaluate, and Document results)

This course will addresses the following student outcomes:

- ability to apply knowledge of mathematics, science, and engineering
- ability to function on multidisciplinary teams
- ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

ASSESSMENT

The course grade will be calculated as follows. Point breakdowns for each of these major components will be posted online.

Mid-term Exam	25%
Homework	25%
Project	25%
Final Exam	25%
TOTAL	100%

Notional numerical grading (i.e. for things like exams) will be as follows.

A: 90-100	A+ 100	A ~95	A- ~92
B: 80-89	B+ ~89	B ~85	B- ~82
C: 70-79	C+ ~79	C ~75	C- ~72

D: 60-69 F: 0-59

With respect to the project, excellent work will receive an A, good work a B, and acceptable work a C. At my option, any unacceptable work may be handed back to redo.

ASSIGNMENTS

In general, homework will be assigned approximately once per week with the assignments due exactly one week later. In exceptional circumstances (illness, university business, religious observances, etc.), extensions may be granted for assignments. However, all extensions should be approved by the instructor BEFORE the due date.

Reading

Students are expected to keep pace with reading the relevant sections within the text and other related literature and should be prepared to discuss it in class.

Homework

Homework assignments will be presented and problem solutions can be discussed upon request in class. Students should consider homeworks as learning experiences. *You may work together on homework, but should work through the problems on your own (i.e., no copying).* The purpose is not just to hand something in, but to use the exercises to understand and gain familiarity with the material/concept being presented.

Project

There will be a project that each student individually will complete through the semester. Students will be asked to create a MATLAB code to model the automated flight of a UAV. The formulation will be based on a series of lecture notes and other material to be provided during the period of the course.

There may be intermediate due dates on components of the project throughout the semester. The reviews of the intermediate reports are to give indication of proper direction, focus and progress. The Student will be expected to report on their progress as requested by the instructor. The grade will be based on the performance / outcome of the code (with attention paid to the intermediate progress/reviews.)

EXAMS

There will be two exams (a mid-term & a final.) Exams will be comprehensive. In grading, consideration is given to the reasoning that is used to solve the problems. It is worthwhile to carefully set up the problem on paper, even if you cannot solve it completely. If you know your answer is wrong, say so and explain why, even if you can't figure out how to get to the right answer. *Show work and explain your reasoning, or partial credit cannot be given.*

ATTENDANCE AND PARTICIPATION

Attendance and active participation are expected. Students are expected to attend class and to draw from the assigned homework material in class participation.

The format of the course will be lecture and discussion. Classroom time offers the opportunity to ask questions about the reading or other topics. Lectures will deal with the general subject matter of the textbook but will also include material not in the text. Students will be expected to discuss the materials that have been covered in class.