Draft 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 UAV flight mechanics. 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 and text leads the student from rigid-body dynamics through aerodynamics, stability augmentation, 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. Students begin by modeling rigid-body dynamics, then add aerodynamics and sensor models. They develop a low-level autopilot code, a path-following routine, and plotting algorithms. Students will further be exposed to small UAV flight through the use of RC aircraft. The students will observe 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
- **TBD**
- **Considering:**
  - **Small Unmanned Aircraft: Theory and Practice**
    by: Randal W. Beard & Timothy W. McLain

MATERIAL

Classroom

The book to be used for the course is to be relatively informative. The class lectures will cover material in the text as well as some additional material. *Instructor will use classroom time to cover the 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 reading the sections of the book or other relate literature associated with the material as it is being covered within the class. Lectures will be presented using Powerpoint while at times being subsidized through whiteboard-based real-time discussions. The lecture notes will be distributed via a series of pdf files. Students are encouraged to seek and review other sources of information in the literature that relates to the course material.

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 knowledge of MATLAB.

Recommended Pre-requisite: Fundamentals of Aerodynamics of Atmospheric Flight Mechanics (ie, ENME 489F) or equivalent.

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 the development, testing and operational use of UAVs. The course will discuss fundamental of UAV autonomous/automated guidance, navigation and control. 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 / Brief History / Why & How to us**e** them
2. Example(s) of commercial and military systems and uses
3. Design/Analysis/Test/Deployment processes
4. Sensors and payloads for UAVs
   (GNC & Mission systems, Resolution vs freq, Atm effect, Absorption/reflection/scatter, Weather effect, handbook calcs, etc.)
5. Navigation systems
6. Controls Systems
   (PID, Sys ID)
7. Guidance / Path Planning / Vehicle Manager
8. Communication systems

9. Flight demos and sample assignment (ie, ISR) (platforms being considered: Quadcopter (Phantom & Quad-Zilla) or other FW RC Aircraft)
    a) Fabricate Quad-copter (kit) platform
    b) Integrate a Pixhawk
    c) Demo RC flight
    d) Demo Auto flight
    e) Tune / vary controller
    f) Demo waypoint flight
    g) Demo auto landing
    h) Optional: Integrate IR camera

10. FAA regulations & UMD UAV Flt Center tour

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

Furthermore, course content provides a description of the a set of key concepts and technologies underlying the development and operation of unmanned aerial systems, and enables all students with 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
  - everyone will fly and evaluate RC aircraft flight articles
- Project
  - "Program", Model and then fly instrumented, RC aircraft (Measure, Analyze, Evaluate, and Document results)

This course will addresses the following student outcomes:

(a) an ability to apply knowledge of mathematics, science, and engineering
(d) an ability to function on multidisciplinary teams
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

SCHEDULE

The class schedule will be distributed. *It is subject to update and change as we proceed through the semester.* When the schedule is changed, the changes will be discussed during class. Students are expected to take note of these and other announcements as they occur.

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

Mid-term Exam	30%
Homework	10%
Project	30%
Final Exam	30%
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 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.
As a courtesy to the professor and the teaching assistant, solutions should be written neatly. Work that is difficult to read may be given a lower grade at their discretion. Show all work, or full credit will not be given.

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 the textbook, a series of lecture notes, and 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 in-class 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.*

Makeup exams will not be given unless a student can present evidence that an absence was caused by serious illness, a death in the immediate family, religious observance, or participation in University activities at the request of University authorities, or another approved reason. Please contact the instructor before an anticipated exam absence, if at all possible. If the student have a documented disability and wishes to discuss academic accommodations, contact instructor as soon as possible at the beginning of the semester.

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.

Fabricate Quad-copter (kit) platform
Integrate a Pixhawk
Demo RC flight
Tune / vary controller
Demo waypoint flight
Demo auto landing
Optional: Integrate IR camera
Optional: FW Demo of RC & Auto flight