

**University Of California, Berkeley**  
**Department of Mechanical Engineering**

**ME 136 – Introduction to Control of Unmanned Aerial Vehicles (3 units)**

Undergraduate Elective

*Syllabus*

**CATALOG DESCRIPTION**

This course introduces students to the control of unmanned aerial vehicles (UAVs). The course will cover modeling and dynamics of aerial vehicles, and common control strategies. Laboratory exercises allow students to apply knowledge on a real system, by programming a microcontroller to control a UAV.

**COURSE PREREQUISITES**

ME132 (or equivalent), ME104 (or equivalent), recommended: ME106

**TEXTBOOK(S) AND/OR OTHER REQUIRED MATERIAL**

To be made available online.

**COURSE OBJECTIVES**

Introduce the students to analysis, modeling, and control of unmanned aerial vehicles. Lectures will cover:

- Principle forces acting on a UAV, including aerodynamics of propellers
- The kinematics and dynamics of rotations, and 3D modeling of vehicle dynamics
- Typical sensors, and their modeling
- Typical control strategies, and their pitfalls
- Programming a microcontroller

During the laboratory sessions, students will apply these skills to create a model-based controller for a UAV.

**DESIRED COURSE OUTCOMES**

At the end of the course, students are able to:

- reason about the dominant effects acting on a UAV
- explain and derive dynamic relationships governing UAV flight
- explain different sensors available on a UAV
- As part of a team:
  - design a nested controller for a quadcopter UAV
  - implement a controller in C++, compile & flash code to a microcontroller

## **TOPICS COVERED**

- Principle forces acting on a UAV, including aerodynamics of propellers
- The kinematics and dynamics of rotations, and 3D modeling of vehicle dynamics
- Typical sensors, and their modeling
- Typical control strategies, and their pitfalls
- Programming a microcontroller

## **CLASS/LABORATORY SCHEDULE**

Three hours of lecture per week, and three hours of laboratory every second week.

## **CONTRIBUTION OF THE COURSE TO MEETING THE PROFESSIONAL COMPONENT**

Students become comfortable working with an advanced robotics system, and related computer tools. Students can reason about practical considerations relating to constrained systems such as UAVs.

## **RELATIONSHIP OF THE COURSE TO ABET PROGRAM OUTCOMES**

- (a) an ability to apply knowledge of mathematics, science, and engineering
- (b) an ability to design and conduct experiments, as well as to analyze and interpret data
- (g) an ability to communicate effectively
- (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

## **ASSESSMENT OF STUDENT PROGRESS TOWARD COURSE OBJECTIVES**

graded laboratory reports [30%]

midterm exam [30%]

final exam [40%]

## **SAMPLE OF WEEKLY AGENDA**

1. Introduction to UAVs: subsystems, main characteristics
2. Introduction to programming the system I
3. Introduction to programming the system II
4. Aerodynamics of a thin aerofoil, propeller dynamics
5. Modeling of rigid bodies
6. Kinematics of rotation, rigid body dynamics
7. Typical sensors: inertial measurement units, GPS, predictor-corrector observer for single state systems applied to tilt estimation
8. Control and stabilization: computing an equilibrium, linearization
9. Nested control loops, application to a UAV
10. Higher-level planning: trajectory generation
11. Higher-level planning: obstacle avoidance
12. Comparison of different vehicle designs: multicopter scaling laws

- 13. Comparison of different vehicle designs: helicopter
- 14. Comparison of different vehicle designs: fixed-wing

**PERSON(S) WHO PREPARED THIS DESCRIPTION**

Mark Mueller, 2017-01-31

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**ABBREVIATED TRANSCRIPT TITLE (19 SPACES MAXIMUM):** INTRO CNT UNMND VEH

**TIE CODE:** LECS

**GRADING:** Letter

**SEMESTER OFFERED:** Fall

**COURSES THAT WILL RESTRICT CREDIT:** None

**INSTRUCTORS:** Mueller

**DURATION OF COURSE:** 15 Weeks

**EST. TOTAL NUMBER OF REQUIRED HRS OF STUDENT WORK PER WEEK:** Varies

**IS COURSE REPEATABLE FOR CREDIT?** No

**CROSSLIST:** None