Instructor: Prof. R. V. Cowlagi, HL 247, rvcowlagi@wpi.edu, http://www.wpi.edu/~rvcowlagi
Instructor Office Hours: Thursdays 3:30 PM – 5:00 PM, otherwise by appointment via email.

Recommended Background: A background in ordinary differential equations (MA 2051) and familiarity with vectors and matrices (MA 2071) are required. Familiarity with MATLAB® is required. A background in 3D kinematics (AE 4733) and introductory control theory (AE/ME 3703, ES 3011) is beneficial but not required.

Course Summary: The goal of this course is for students to apply control theoretic tools to aircraft, with an emphasis on the autonomy of small unmanned aerial vehicles (UAVs). Topics include: flight dynamics and simulation, trim stabilization and control augmentation, trajectory planning and tracking, and vision-based navigation for small UAVs.

Course Objectives: The goal of this course is to apply control theoretic tools to aircraft motion. Specifically, the students will:
1. Review and analyze aircraft rigid body dynamics, including the effects of aerodynamic and propulsive forces and moments. Develop numerical simulation models of aircraft motion.
2. Review sensing and navigation equipment, and estimation algorithms, for small UAVs.
3. Develop and test aircraft autopilots.
4. Review trajectory generation algorithms; develop and test controllers for trajectory tracking.
5. Review selected topics on small UAV autonomy, including vision-based navigation and sense-and-avoid.

Course Outline:
- Aircraft modeling and simulation:
  - 3D kinematics: Euler angles and quaternions.
  - Rigid body dynamics: Euler’s equations.
  - Modeling of fixed-wing aircraft and quadrotor aircraft.
  - Longitudinal and lateral aerodynamic forces and natural modes of motion.
  - Numerical simulation.
- Trim stabilization and control augmentation:
  - Sensors in small UAVs and state estimation.
  - Autopilot functions and successive loop closure.
  - Quadrotor stabilization and control augmentation.
- Trajectory planning and tracking:
  - Aircraft models for guidance and trajectory planning.
  - Trajectory planning methods.
  - Path management: straight-line and orbit following.
- Small UAV autonomy
  - Vision-based navigation.
  - Airborne sense-and-avoid.

Textbook:

This textbook is strongly recommended, but not required. Lecture notes and additional reading material will be provided as appropriate.
Additional recommended reading:


Performance Evaluation: Homework assignments (20 pts), Midterm exams (40 pts), Final project (40 pts)

- Two midterm exams will be administered, tentatively on 02/03/2016 and 02/24/2016.
- A course project will be assigned.
- The following rubric will be used for grading each problem in all assignments and exams:
  - 0%: Solution missing.
  - 20%: Minimal progress made towards solution.
  - 40%: Moderate progress towards solution, but incorrect approach or incomplete answer.
  - 60%: Significant progress towards solution and all work shown, but incomplete answer.
  - 80%: All work shown, correct approach, minor errors.
  - 100%: All work shown, correct approach, correct answer.
- The course grade for each student will be assigned based on the weighted sum of points received by that student in each assignment.

Policies and Guidelines:

- Students are expected to attend all class lectures and tutorial sessions. Whereas lecture notes and slides will be provided, students are encouraged to make their own notes in class.
- Students are expected to return all assignments and take-home exams by the due dates and times. Late submissions will be penalized according to the following rubric (unless otherwise specified):
  - Late by up to 24 hours after due: 20% penalty.
  - Later than 24 hours, up to 48 hours after due: 30% penalty.
  - Later than 48 hours after due: assignment will not be accepted, and all points for that will be forfeited.
- Illegible and/or untidy homeworks and exams will not be accepted or graded, and the students will forfeit points unless the work is entirely resubmitted. For these resubmissions, lateness penalties as described above will apply. The determination of “illegibility” and “untidiness” is solely based on the subjective judgment of the instructor and/or the TA.
- Cheating and plagiarism on any assigned homework, exam, or project will result in forfeiture of all points associated with that assignment. Students are strongly encouraged to study the WPI policies on academic honesty, which may be found at [http://www.wpi.edu/offices/policies/honesty/policy.html](http://www.wpi.edu/offices/policies/honesty/policy.html).
- When possible, the students are required to inform the instructor of potential difficulties in advance. Most problems can be handled over email. Students should individually inform the instructor, by January 20, 2016, of any long-standing commitments (i.e. religious observances, varsity team athletic events, etc) that may affect their ability to meet the class requirements, for alternative arrangements to be considered.
- Students in need of course accommodations because of a disability should make an appointment with the instructor as soon as possible. Additionally, students are encouraged to contact the Office of Disability Services (ODS), as soon as possible to ensure that such accommodations are implemented in a timely manner. The ODS is located at 157 West Street, (508) 831-4908, DisabilityServices@wpi.edu.