Instructor: Prof. R. V. Cowlagi, HL 247, rvcowlagi@wpi.edu, http://www.wpi.edu/~rvcowlagi
Instructor Office Hours: Mondays and Thursdays 3:30 PM – 4:30 PM, otherwise by appointment via email.

Teaching Assistant: Ms. Lakshmy Krishna Moorthy, HL 310
TA Office Hours: Mondays 10:30 AM – 12:30 PM, Wednesdays 11:30 AM – 12:30 PM

Recommended Background: A background in ordinary differential equations (MA 2051) and familiarity with vectors and matrices (MA 2071) are required. A background in introductory control theory (AE/ME 3703, ES 3011) and orbital mechanics (AE/ME 2713 or AE 4713) are recommended. Familiarity with MATLAB® is recommended.

Course Summary: The theory and practice of guidance and navigation systems in aerospace engineering is introduced. The practices of satellite navigation systems, including an overview of satellite communication systems, and aeronautical dead-reckoning navigation systems are discussed. The theory of optimal state estimation from noisy measurements is introduced in the context of multi-sensor navigation.

Course Objectives: By the end of this course, the students are expected to
1. Develop an understanding of the Global Positioning System.
2. Develop an understanding of the state-of-the-art in aerospace guidance and navigation systems.
3. Develop an understanding of the reference frames used in global navigation, and learn to transform measurements from one frame to another.
4. Develop an understanding of system-level concepts of the communications technology used in satellite navigation.
5. Develop an understanding of inertial sensors and platforms to acquire position and velocity measurements.
6. Develop familiarity with the theoretical concepts of least squares estimation and of the Kalman filter, and with the application of these concepts to guidance and navigation.

Course Outline:
- Introduction: terminology, context, scope, overview of navigation systems (1 lecture)
- Inertial navigation systems (10 lectures)
  - Reference frames, mechanization equations
  - Instruments and platforms: accelerometers, gyroscopes, heading reference
- Aircraft and missile guidance (2 lectures)
- Optimal state estimation (10 lectures)
  - Least squares estimation, Kalman filter
  - Application to GPS-INS integration
- The Global Positioning System (4 lectures)
  - Overview of global navigation satellite systems (GNSS)
  - GPS-based position, velocity, and time measurements
  - Satellite communications for GNSS
- Overview of satellite communications (1 lecture)

Textbook: There is no required textbook. Lecture notes and additional reading material will be provided.

Recommended Reading:

These textbooks are excellent references. However, students are not required to purchase these textbooks.

**Performance Evaluation:** Homeworks (25 pts), Quizzes (30 pts), Midterm exam (20 pts), Final project (25 pts)

- Homeworks will be assigned approximately once per week.
- One midterm exam will be administered during the third or fourth full week of classes.
- Short quizzes will be administered during the conference / tutorial sessions on Wednesdays.
- A final project will be assigned. Project reports will be due on the last day of classes.

The following rubric will be used for grading each problem in all assignments:

- 0%: Solution missing.
- 20%: Minimal progress made towards solution.
- 40%: Minimal progress made towards solution and some of the work shown, 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 sum of points received by that student in each assignment (homework, mid-term exam, final project).

**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 complete homework solutions by the due dates. Late submissions will be penalized according to the delay in submission.
- Illegible and/or untidy homeworks and exams will not be graded, and the students will forfeit points unless the work is entirely resubmitted. 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 September 2, 2015, 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.