University of Illinois at Urbana Champaign
Department of Aerospace Engineering
Fall 2019

AE 353: Aerospace Control Systems

4 credit hours

This syllabus is not an exhaustive description of all details of the course; you are free to contact the instructor with any additional questions or concerns at any time.

Personnel

Instructor: Melkior Ornik (mornik@illinois.edu), 319H Talbot
TA: Pranay Thangeda (pranayt2@illinois.edu)

Contact and Office Hours

The primary mode of communication will be Piazza. The course website for this semester is https://piazza.com/illinois/fall2019/ae353. If you do not receive an invitation to enroll in Piazza for this course, please join by yourself. *All important announcements will be communicated over Piazza*.

You are welcome to either send a Piazza message or email the instructor or the TA with questions about the course logistics, but all questions on the course material *must* be posted on Piazza – publicly, if there is no reason to do otherwise. Any emailed questions on the materials will remain unanswered. You are encouraged to answer each other's questions; the instructor and the TA will answer the questions that have not been answered by students after an appropriate amount of time.

The instructor's office hours are – generally – Mondays and Wednesdays before class: 11-11:50am. As unplanned events tend to come up surprisingly often, please send a message prior to coming for office hours.

The TA will be available for office hours by appointment.

Office hours are primarily intended for high-level conceptual help: do make sure that you try to find an answer to any specific questions, first by yourself and then by posting the question to Piazza, before coming to office hours.

Lecture Times

While lectures will generally be held on MWF 12-12:50pm, the dynamic nature of the class will require frequent exceptions – particular classes will be canceled or replaced by optional office hours and study sessions in order for students to prepare for their exams or projects. (A *tentative* and incomplete list of possible class cancelations: Sep 18, Oct 9, Oct 29, Nov 18, Dec 9, Dec 11.) There may be optional workshops to help students having trouble with certain computing aspects of the class, as well as live

demonstrations of the concepts learned in class, in lieu or in addition to standard lectures. All such changes will be announced during the semester.

Attendance at lectures is *not* mandatory – students are welcome to adjust their course experience to their learning style, as long as doing so does not disturb learning styles of the others.

Course Description

AE 353 is a modern, challenging aerospace take on a standard undergrad controls course. It seeks to use formal mathematical methods to answer a fundamental engineering question: *How can I ensure that the system does what I want it to do?*

On a more technical level, the primary objective of the course is to expose students to the notion of continuous-time, continuous-space controlled system dynamics, and explore the design of control signals to drive the system to a desired outcome. We will do so by formulating *state space representations*, relating the system's control inputs, states, and outputs through a set of ordinary differential and algebraic equations. Even when such relationships are simple, performing control design in such a representation will require us to develop the method for computing a solution to a system of ordinary differential equations: the notion of a *matrix exponential* plays a significant role. Using a significant amount of linear algebra, we will then devote a large part of the course to discussing some of the central questions of control theory: *can I drive the system to a particular state?* (controllability)*, how can I do it in the quickest or cheapest way possible?* (optimal control), and *can I do it even if I don't know everything about the system at every given time?* (observability)*.* Finally, we will connect the developed machinery of modern state-space-based control design to a classical method of frequency-domain-based control design – a "dual" of the state space representation that often simplifies control design methods, but pays the price of reduced applicability to more complicated dynamics models and control objectives.

Grading

The deliverables for the course will consist of:

- Many (~26) homework assignments,
- four 50-minute quizzes,
- four design problems, and
- a 3-hour final exam.

The weights for the deliverables will be nominally distributed as follows:

Homeworks: 20% total (around 0.77% each)
Quizzes: 20% total (5% each)
Design problems: 40% total (10% each)
Final exam: 20%

Additional extra credit may be offered during the semester.

The final grades will be calculated by the following formula: A-/A/A+ = 90-100, B-/B/B+ = 80-89.99, C-/C/C+ = 70-79.99, D-/D/D+ = 60-69.99, F = 0-59.99, where the "-" modifier will be assigned to those grades with the unit digit 0-1 (e.g., 91.87 = A-) and "+" modifier to those grades with the unit digit 8-9 (e.g., 78.02 = C+). The grades will *not* be rounded up, rounded down, nor "curved".

Submission of Deliverables

Homework assignments will be completed online using PrarieLearn. You are allowed, and encouraged, to discuss these assignments with your peers.

Quizzes will be taken in the Computer-Based Testing Facility (CBTF); you will be responsible for scheduling your own quiz within a given interval of dates. The *tentative* schedule of quizzes is:

- Quiz 1: Sep 19-21
- Quiz 2: Oct 10-12
- Quiz 3: Oct 31-Nov 2
- Quiz 4: Nov 20-22

You will have 50 minutes to complete the quiz. You will receive your results immediately, and will be allowed to retake each quiz *exactly once*. The retakes will take place one or two weeks after the original attempts, again in CBTF. The tentative schedule of retakes is:

- Retake 1: Sep 26-28
- Retake 2: Oct 17-19
- Retake 3: Nov 7-9
- Retake 4: Dec 6-9

If you retake a quiz, your score will be computed as follows: 0.9x(amount of points on the better attempt) + 0.1x(amount of points on the worse attempt).

You are not allowed to communicate with the outside world during the quizzes. Any problem with testing in the CBTF *must* be reported to CBTF staff at the time the problem occurs. If you do not inform a proctor of a problem during the test then you forfeit all rights to redress. Practice quizzes will be provided prior to the quiz dates, but they do not bring any amount of credit.

The design problems will require you to submit MATLAB code and a report written in LaTeX. Both will be submitted online, using Box or a different agreed upon method. You are encouraged to talk with your colleagues about these design problems, so long as you acknowledge the colleagues with whom you talked in your report. Materials submitted must be your own. You may also be required to review several of your peers' submissions as a second stage of each project.

The final exam will also be taken in CBTF. It will last 3 hours, and cannot be retaken. You are not allowed to communicate with the outside world during the exam.

You are responsible for timely submission of the deliverables. Late submission of a particular deliverable, if not agreed with the instructor, may be penalized at the rate of up to 50% of the total weight of the

deliverable. There may be bonus points for early submissions, equaling no more than 5% of the total weight of the deliverable.

Emergencies do happen; when faced with unavoidable obstacles, students should contact the instructor for any modifications to the submission schedules.

Prerequisites and Literature

The formal prerequisites for the course are credit in MATH 225, MATH 285, and TAM 212 (or equivalent). You cannot take this class for credit if you have already taken GE 320 or ME 340.

There is no required text for the course. With possible small exceptions intended for independent study, all new topics required for success in the course will be discussed during the lectures.

The course material will partly overlap with the following textbooks:

- *Feedback Systems: An Introduction for Scientists and Engineers*, K. J. Åström and R. M. Murray
- *Control System Design: An Introduction to State-Space Methods*, B. Friedland
- *Feedback and Control for Everyone*, P. Albertos Pérez and I. Mareels
- *Feedback Control of Dynamic Systems*, G. F. Franklin, J. Da Powell, and A. Emami-Naeini
- *Feedback Control Systems*, C. L. Phillips and J. Parr
- *Modern Control Engineering*, K. Ogata
- *Modern Control Systems*, R. C. Dorf and R. H. Bishop

You are not required to purchase any textbooks or other materials. The first book on the list above was made freely available by the authors and can be found online. All of the books on the list have been placed on reserve for the course in the Grainger Library. Please note that, while each of above books has substantial overlap with the course material, the material covered will be significantly smaller than the material of the union of these books.

Academic Integrity

While you are welcome to consult your peers on their homework assignments and design problems, you are required to write solutions and on their own *and* respond to any subsequent questions on the material posed by the instructor, whether in person or over email. The answers to the instructor's questions may play a role in the assigned grade.

You are expected to work entirely alone on the quizzes and the final exam. The policies of the CBTF are the policies of this course, and academic integrity infractions related to the CBTF are infractions in this course.

You are required to familiarize themselves with the University's Academic Integrity Policy and Procedure, available at http://studentcode.illinois.edu/article1/part4/1-401/, and abide by that policy in full.

Accommodations

To obtain disability-related academic adjustments and/or auxiliary aids, you must contact the instructor and the Disability Resources and Educational Services (DRES) as soon as possible. You are welcome to contact the instructor at any time with any accommodation-related needs. To contact DRES you may visit 1207 S. Oak St., Champaign, call 217-333-4603 (V/TTY), or email disability@illinois.edu.

If you have accommodations identified by the DRES for exams, please take your Letter of Accommodation (LOA) to the CBTF proctors in person before you make your first exam reservation. The proctors will advise you as to whether the CBTF can provide for your accommodations or whether you will need to make other arrangements with the instructor.

Modifications to the Syllabus

The instructor reserves the sole right to modify any and all parts of this syllabus throughout the semester. All modifications will be made solely in the interest of time scheduling, accurately measuring the students' success, and improving the students' educational outcomes.