SE 424
State-Space Methods for Control Design and Analysis
MWF 1-1:50 PM

Instructor: Prof. Carolyn Beck, *beck3@illinois.edu*
office hours: via Zoom, Tuesdays 1-2pm

TAs: Vincent Hoff: *vhoff2@illinois.edu* and Xiaotian Xie: *xx5@illinois.edu*
office hours: via Zoom, TBD

Required Text: *Feedback Systems*: *An Introduction for Scientists and Engineers*, by Karl Åström and Richard Murray (Å&M), Princeton University Press
NOTE: available on course Compass 2g site, and online:
http://www.cds.caltech.edu/∼murray/amwiki/index.php/Second_Edition

Recommended: *GE 424 Course Packet*, Lecture Notes by Prof. R.S. Sreenivas (Notes)

Spring 2021 semester non-instructional days:
Wed-February 17th, Wed-March 24th, Tues-April 13th

Course delivery:

- Synchronous lectures will be delivered via Zoom on most Monday-Wednesday course days; these will also be recorded and posted on Compass with the lecture notes within the week following the lecture.
- Pre-recorded lectures will be posted on Compass on Thursdays for Friday course day lectures; many of these pre-recorded Friday lectures will be approx. half-length, with the remainder of the lecture time on Friday being used for **live-video** quizzes...
- Short **live-video** quizzes (about 10-20 min) will be held most Fridays at 1:30pm; tentatively on every Friday excepting Jan 29, Feb 19, Mar 26 and Apr 16. *Students will be required to have their video on while they take the quiz.*
- For students in later time-zones, or by arrangement, an earlier quiz time can be offered Friday mornings at 9:30am Central time: details TBD.
- If you would like to audit the course, please contact Prof. Beck in order to be added to the Compass course site.

TENTATIVE COURSE OUTLINE:

Reading	Topics	Lectures
Å&M: Chapters 1-4, 6, 9 **Notes: Parts 1, 3 and 7**	Review of SE 320/Introduction to state-space models. Examples; Intro. to linearization of nonlinear systems; Laplace transforms; Relating differential equations, transfer functions and state-space models	Weeks 1-4
Å&M: Chapter 6 **Notes: Part 2** **Handouts**	Linear algebra fundamentals: linear independence, range space, null space, change of basis/similarity transformations; eigenvalue decomposition, Jordan form, Cayley-Hamilton theorem, singular value decomposition	Weeks 5-7
Å&M: Chapters 6, 9 **Notes: Part 3**	Solutions to state equations: matrix exponentials, convolution integrals and Laplace methods	Weeks 7-9
Å&M: Chapter 5 **Notes: Parts 1 and 7**	Stability: definition of stability; tests for state-space stability; poles and eigenvalues; Lyapunov stability	Weeks 9-10
Å&M: Chapter 7 **Notes: Part 4**	Reachability and state feedback design; decomposition structures, duality	Weeks 11-13
Å&M: Chapter 8 **Notes: Part 5**	Observability and state estimation, separation principle, error dynamics	Weeks 13-14
TBD	Advanced Topics: linear-quadratic regulator design, optimal control methods, linearization of nonlinear systems	Weeks 14-15

Assignments and Exams:

- Problem sets will be assigned approximately every-other-week, and will include MATLAB-based exercises. Homework should be submitted as a scanned pdf to Gradescope by 11:59pm Central Time on the due date, or earlier (for example if there is a conflict for the student).
- Two or three problems will be selected randomly from each assignment for grading. Solutions for all problems will be provided on Compass.
- **Late homework policy:** each day a homework assignment submission is late, a 10% deduction will be taken off the score, for up to seven days. Late homework more than one week late will not be accepted.
- There will be weekly **in-class quizzes on most Fridays**. Scanned pdf or photos of the quizzes should be submitted to Gradescope by 2pm (or 10am for morning quiz takers) on Fridays. Missed quizzes can only be made up due to illness or unavoidable conflicts, and only if Prof. Beck is notified **in advance**, with justification provided by the student.
- There will be one MATLAB-based control design and analysis project toward the end of the semester.
- There will be a 3-hour **live-video** final exam during the regular final time slot.

Course Grade Composition:

Item	% of grade
Homework Problem Sets	25% total
Quizzes	25% total
Design Project	25%
Final Exam	25%

Grading policy:

1. Any student attaining a total weighted average (TWA) of 90% or above is guaranteed an A- or above.
2. Any student attaining a TWA of 79% or above is guaranteed a B- or above.
3. Any student attaining a TWA of 67% or above is guaranteed a C- or above.
4. Any student attaining a TWA of 55% or above is guaranteed a D- or above.
5. This grading scale will be curved as appropriate; specifically, at a minimum the top 20% of the class is guaranteed an A- or above.

General Course Policies

Academic Integrity: The University of Illinois at Urbana-Champaign Student Code is also considered as a part of this syllabus. In particular, students should note Article 1, Part 4: Academic Integrity, which you can read at the following URL: http://studentcode.illinois.edu/. Note that academic dishonesty may result in a failing grade. Every student is expected to review and abide by the Academic Integrity Policy. Ignorance will not be allowed as an excuse for any academic dishonesty. Do not hesitate to ask me if you are ever in doubt about what constitutes plagiarism, cheating, or any other breach of academic integrity. Specific to SE 424, note the following:

- Although you are allowed to discuss homework assignments and Matlab project problems with your classmates, you are expected to produce your own work in these assignments. Written assignments will be submitted through Gradescope, a software tool that facilitates comparison of your work to the work of your current classmates and previously submitted assignments. Assignments with close matches to other work will be flagged and investigated.
- Quizzes and exams must be completed entirely alone. No cell phones or electronic devices that allow for communication with others are allowed during quiz or exam times. Such usage will be monitored and if you are found using these, it will be investigated as potential cheating.

Students with disabilities: To obtain disability-related academic adjustments and/or auxiliary aids, students should contact the course instructor as soon as possible. To insure that disability-related concerns are properly addressed from the beginning, students with disabilities who require assistance to participate in this class should contact Disability Resources and Educational Services (DRES) and communicate the results to the instructor as early in the semester as possible. If you need accommodations for any sort of disability, please speak do not hesitate to make an appointment to see me to discuss. DRES provides students with academic accommodations, access, and support services. To contact DRES you may visit 1207 S. Oak St., Champaign, call 333-4603 (V/TDD), or email a message to disability@uiuc.edu. http://www.disability.illinois.edu/.

Inclusivity: The Grainger College of Engineering is committed to the creation of an anti-racist, inclusive community that welcomes diversity along a number of dimensions, including, but not limited to, race, ethnicity and national origins, gender and gender identity, sexuality, disability status, class, age, or religious beliefs. The effectiveness of this course is dependent upon each of us to create a safe and encouraging learning environment that allows for the open exchange of ideas while also ensuring equitable opportunities and respect for all of us. Everyone is expected to help establish and maintain an environment where students, staff, and faculty can contribute without fear of personal ridicule, or intolerant or offensive language.

FERPA: Any student who has suppressed their directory information pursuant to the Family Educational Rights and Privacy Act (FERPA) should self-identify to the instructor to ensure protection of the privacy of their attendance in this course. See http://registrar.illinois.edu/ferpa for more information on FERPA.