Course Information

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Phone: 646-997-3681  
Office Hours: Tuesday 5:00-5:55  
Lecture: Thursday 6:00-8:30 JAB674  
Webpage: NYU Classes

Course Goals

This course presents the theory of linear systems, with a focus on traditional topics in classical control theory, and application to mechanical systems. Topics include state space representation and analysis, stability, control systems design, controllability, observability, realizability, and linear state feedback.

Prerequisites

It is assumed that all students have a working familiarity with matrix/vector analysis and differential equations. Applied Mathematics in Mechanical Engineering is a highly recommended co-requisite, although it is not required.

Suggested Textbooks


Homework

Five homework assignments will be given; three focused on theory and two on numerics. Each homework assignment must be typed on a word-processor. Use of LaTeX is encouraged, although other word processing platforms are certainly acceptable. Students must upload on NYU classes their homework. Students are permitted to discuss homework questions with other students, although they are not permitted to discuss solutions except in general terms. No late homework will be accepted except for exceptional and documented circumstances. Solutions for all assigned problems will be provided, although not all assigned problems will necessarily be graded. Significant weight in grading will be placed on clarity of presentation.

The five homework assignments are due on Mondays at noon:

1. 7 October 2019 (Theory)
2. 21 October 2019 (Theory)
3. 18 November 2018 (Numerics)
4. 16 December 2019 (Theory)
5. 16 December 2019 (Numerics)

Exams
There will be two exams, each covering roughly a half of the program. The exams will be administered in class and will test the student’s comprehension and ability to apply material learned in class and through assignments. The tests are open book (one book of the student’s choice in the list of three above) and closed notes. Formula sheets prepared by students will not be allowed. During each test, before beginning to solve assigned problems, students should briefly restate the problem and list the data given. Also, students should list the important concepts and formulae used to arrive at the final solution along with detailed work. Every page of every exam submission should have the student full name and section number. Illegible work and loose sheets will not be graded. Students must complete the exam on their own. If a student cannot attend an exam due to a medical condition, certified by a doctor, he/she must notify the instructor in advance. Unexcused absence from an exam will result in a grade of 0 for that exam.

Grading policy
Homework: 25%
Exam 1: 35%
Exam 2: 40%
The passing grade is 60%.

Extra credit
There are no opportunities for extra credit. The grading policy allows for a “bad score”.

Class attendance and absences
There are no formal requirements for attendance, and there is no direct penalty for missing class. Students are strongly encouraged to attend class since some course material will only appear in lectures. Students that miss class are responsible for obtaining class notes from a classmate.

Honor system
The honor system is in strictly force for this course. It is assumed that all work submitted by a student is done so under the honor system code. Homework questions may be discussed with students. Homework solutions may not be discussed. The final exam must be completed individually.

ABET a-k criteria compliance

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(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
(c) an ability to design a system, component, or process to meet desired needs
(d) an ability to function on multi-disciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Tentative Lecture Schedule

Due to prior travel commitment, the lectures on 9/19/19 and 9/26/19 will not take place. One will be regularly made up by having the second exam on the day of the Finals and for the others I need your help to identify another day that we will use for review and filling few gaps toward the end of the course.
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<thead>
<tr>
<th>Lecture</th>
<th>Reading</th>
<th>Topic of the day</th>
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<tbody>
<tr>
<td>Lecture 1</td>
<td>R 1, AM 1 and Appendix A, and C3</td>
<td>Review of relevant mathematics (vector spaces, ordinary differential equations, matrix diagonalization, and Laplace transform)</td>
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<tr>
<td>Lecture 2</td>
<td>R 2, AM 2, and C 2</td>
<td>State equation representation and input/output description (examples from mechanics, block diagrams, and linearization about fixed equilibria or trajectories)</td>
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<td>Lecture 3</td>
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<td>Lecture 4</td>
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<tr>
<td>Lecture 5</td>
<td>R 3, AM 3, and C4</td>
<td>State equation solution (analytical methods and numerical techniques in the time and Laplace domains, examples from mechanics, modes, role of initial conditions, assessment of unmodelled nonlinearities)</td>
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<tr>
<td>Lecture 6</td>
<td>R 4–5, AM 3, and C 4</td>
<td>Transition matrix (time-varying systems: including examples of switched systems and elements of numerical implementation/discretization and time-invariant systems: detailed analysis of the matrix exponential)</td>
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<tr>
<td>Lecture 7</td>
<td>R 4–5, AM 3, and C 4</td>
<td>More on transition matrix</td>
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<td>Lecture 8</td>
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<td><strong>Exam 1</strong></td>
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<td>Lecture 9</td>
<td>R 6, AM 4, and C 5</td>
<td>Internal stability (general case of time-varying systems, with care towards notions of uniformity, and examples of nonlinear systems)</td>
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<td>Lecture 10</td>
<td>R 7, AM 4, and C 5</td>
<td>Lyapunov stability criteria and input-output stability (analytical methods and numerical techniques, exemplary applications to mechanical systems examples from mechanics)</td>
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<td>Lecture 11</td>
<td>R 9, AM 5, and C 6</td>
<td>Controllability (focus on time-invariant systems, with insights on time-varying systems)</td>
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<td>Lecture 12</td>
<td>R 9, AM 5, and C 6</td>
<td>Observability (focus on time-invariant systems, with insights on time-varying systems)</td>
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<td>Lecture 13</td>
<td>R13, AM 6, and C 6</td>
<td>Special forms for state-space descriptions of linear time-invariant systems (controllable and observable forms, Kalman decomposition)</td>
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<td>Lecture 14</td>
<td>R 14–15, AM 9, and C 8–9</td>
<td>State feedback and state observers (focus on time-invariant systems, pole placement, application to mechanical systems)</td>
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<td>Lecture 15</td>
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<td>Tightening up loose ends and review of relevant material</td>
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