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ENG ME/SE/EC 501: **Dynamic Systems Theory — State-space linear systems**

Course Outline: (Fall 2021)

1. Mathematical preliminaries: linear algebra
   (i) Finite dimensional linear spaces
   (ii) Linear transformations and matrices
   (iii) Jordan normal form
2. State-space representation of linear control systems
3. Mathematical foundations of state-space representations
   (i) Existence and uniqueness results for linear ordinary differential equations
   (ii) Peano-Baker series and matrix exponentials
   (iii) Properties of the state-transition matrix
4. Points of contract with frequency-domain analysis
   (i) The resolvent; Newton's algorithm
   (ii) Stability analysis in the frequency domain
5. Controllability and observability
   (i) The controllability Grammian; the observability Grammian
   (ii) Algerbaic tests for controllability and observability
6. Shaping the dynamic response — Where do we put the closed-loop poles?
   (i) Analysis of second-order systems; dc-motor control example
   (ii) Design of regulators
7. Digital control theory
   (i) Modeling discrete-time and sampled-data systems
   (ii) Analysis of sampled data systems
8. Linear observers
9. Compensator design by separation of variables principle
10. Linear quadratic optimal control theory
    (i) The Pontryagin maximum principle
    (ii) Least squares theory and the matrix Riccati equation
11. Introduction to stochastic processes and stochastic control processes
    (i) Wiener processes
    (ii) The Ito calculus and the theory of stochastic differential equations
    (iii) Recursive estimation

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12. Nonlinear/geometric control theory
    (i) Introduction to the theory of differentiable manifolds
    (ii) Accessibility, controllability, and system Lie algebras
    (iii) Geometric mechanics and control of mechanical systems

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Suggested Reading

Text:

Roger W. Brockett, *Finite Dimensional Linear Systems*, SIAM, 2015 / xvi + 244 pages / Softcover / ISBN 978-1-611973-87-7. For student discount prices, order according to the instructions given on the course web site: http://people.bu.edu/johnb/ME501.html.

For a convenient guide to online shopping for the text, visit the course website:
`http://people.bu.edu/johnb/ME501.html`

Other books:

Panos J. Antsaklis & Anthony N. Michel, *Linear Systems*, ISBN: 0-07-041433-5, Electrical and Computer Engineering Series, McGraw-Hill, 1997, 696 pages.

Chi-Tsong Chen, *Linear System Theory and Design*, Oxford University Press, 3-rd Edition, ISBN 0-19-511777-8, 1999, 334 pages.

Karl Johan Åström and Richard M. Murray, *Feedback Systems: An Introduction for Scientists and Engineers*, Princeton University Press, ISBN-13: 978-0-691-13576-2, ISBN-10: 0-691-13576-2, 2008, 396 pages.

João P. Hespanha, *Linear Systems Theory*, Princeton University Press, ISBN: 978-0-691-14021-6, 2009, 278 pages.

Roger W. Brockett, *Finite Dimensional Linear Systems*, John Wiley and Sons, SBN 471 10585 6, 256 pages. (Out of print. See http://www.amazon.com/ or download from course web site `http://people.bu.edu/johnb/ME501.html`. Alternatively, use the identical SIAM reissue listed above.)

Grading

Grades will be given for homework assignments (one every week or so), class participation, and a mix of quizzes and exams—the numbers of which will be determined by whether the University decides to flip to online delivery of courses.

For up-to-date information about the class, visit: `http://people.bu.edu/johnb/ME501.html`.

(August 26, 2021)