ECSE-6400: Systems Analysis Techniques
FALL 2011

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Classroom: JEC 4304/ MR 4 – 5:20pm
DCC 232/ W 4 – 5:20pm
Credit hours: 3 units
Textbook: DeRusso et al, State Variables for Engineers 2ed, Wiley Interscience, 1998.
Website: RPILMS

Grading:

Homework (6 sets)	25%
Midterm Exam 1+2	15% + 20%
Final exam	40%

• Homework sets are due one week after hand-out at the end of the class. For each day late (**3 days max**), there is a 20pt penalty.
• **Homework handout dates**: 9/1, 9/29, 10/17, 10/27, 11/7, 12/1.
• There will be two (2) midterm exams in class.
• **Midterm exam dates**: 10/13 and 11/17.
• Final exam date will be announced later.
• The worst homework grade will be dropped. Use this to accommodate for emergencies, sickness, etc.

Prerequisites: ECSE 2410 (Signal and Systems) or equivalent, working knowledge of linear algebra and MATLAB.

Summary:
This course trains the students in the state-space theory for linear systems. Various related concepts, such as state-space model derivation, controllability & observability, and controller design for pole placement are covered. In addition to that, the course will review linear algebra and matrix theoretic concepts that are relevant to the state-space theory, with their applications. Linear quadratic functions are also discussed in relation to Lyapunov stability theory and linear quadratic optimization in optimal estimation and Kalman filtering. In this course, some computation tasks will be done with MATLAB.

Learning Outcomes:
The students are expected to:

- understand the concept of state variables and how to derive them from different linear system representations.
- know how to solve a system of linear differential equations in state space form.
- understand the geometric aspect of linear state-space, including the concepts of eigenvalues decomposition and singular value decomposition.
- understand the concepts of controllability and observability in linear systems,
- be able to perform controller design for stabilization and pole placement for linear systems,
- understand the principles behind least squares estimation and discrete-time Kalman filtering.

Statement of academic integrity:
The Rensselaer Handbook of Student Rights and Responsibilities defines various forms of Academic Dishonesty and the students should make themselves familiar with these. All homework, quizzes and exam are expected to be individual work. You are allowed to work together for the homework. However, the writing must be your own (copying is not acceptable). One instance of unacceptable collaboration or plagiarism will result in 0 point for the work. A second instance of academic dishonesty will result in failure of the course.

Tentative Course Outline:

Session	Topic	Remark
1	Intro, course structure, course overview.	
2	Simulation diagram, state-space representation from transfer function, and vice versa.	
3	Math review: complex numbers, linear spaces, basis, inner product.	
4	…cont'd..basis, orthonormal basis, Gramm-Schmidt procedure	
5	Transformation of state variables, intro to diagonalization, computing matrix exponential for diagonal matrices	
6	Eigenvalue decomposition, diagonalization	
7	Diagonalization with non-distinct eigenvalues	
8	Similarity Transformations, Generalized Eigenvectors, Jordan Form	
9	Matrix exponential of Jordan forms, Cayley-Hamilton Theorem	

10	Cayley – Hamilton technique for computing analytic functions of square matrices	
11	Computing matrix exponentials with Cayley-Hamilton technique and Laplace Transform	
12	Singular value decomposition	
13	Discrete Time Linear Systems	
14	Discrete Time Controllability and Observability	
15	Discrete Time Observability and Continuous Time controllability	
16	Continuous Time Observability, Controller Canonical Form	
17	Full State Feedback, Pole placement, Observer Canonical Form,	
18	Intro to observer and observer design, reduced order observer	
19	Output feedback control and separation principle	
20	State space factorization and minimal representation	
21	Intro to stability and asymptotic stability, physical interpretation	
22	Lyapunov functions, quadratic forms	
23	Quadratic Lyapunov Functions, Lyapunov equation, Grammians	
24	Discrete-Time Least Square Estimation	
25	Review of Random Variables, and linear spaces of RVs	
26	Discrete-Time Kalman Filter	