

**CARLETON UNIVERSITY**  
**Department of Systems and Computer Engineering**

**SYSC 5502**

**Advanced Linear Systems**

**Fall 2011**

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**Course Outline**

**Instructor:**

Professor V. Aitken, Room 4488ME, E-mail [vaitken@sce.carleton.ca](mailto:vaitken@sce.carleton.ca)

**Course Objectives:**

To develop a basic graduate level understanding of the behavior and control of linear dynamical systems. Integrated development of state space methods, controllability and observability, state variable feedback, observer and compensator design. Both continuous and discrete-time systems are considered. Brief introductions to optimal control, the Kalman Filter, and nonlinear systems are given.

**Prerequisites:**

Prior exposure to linear system dynamics, preferably from an undergraduate course in classical control methods.

**Textbooks:** Students may find the following textbooks useful for some course components.

K. Ogata, “*Modern Control Engineering, 4<sup>th</sup> Edition*” Prentice Hall 1997, ISBN: 0-13-227307.  
S.H. Zak, “*Systems and Control*”, Oxford Press, 2003, ISBN: 0-19-515011-2.

**References:**

- B. Kuo, Automatic Control Systems, Prentice Hall
- W. Palm, Control Systems Engineering, Wiley
- Hostetter et al, Design of Feedback Control Systems, Holt Rinehart and Winston
- Bateson, Introduction to Control System Technology, Merrill
- Goodwin, Control System Design, Prentice Hall
- Dorf, Modern Control Systems, Prentice Hall
- T. Kailath, “*Linear Systems,*” Prentice Hall 1980, ISBN: 0-13-536961-4

**Grading Scheme:**

- Assignments (3)                    30%
- Midterm                                20% (To be scheduled, in class)
- Final Exam                            50% (During December examination period)

**Note:**

Students **must pass the Final Examination Paper** (50% or higher) in order to pass the course.

**Students with Disabilities:**

Students with a disability who require academic accommodations in this course are encouraged to contact a coordinator at the Paul Menton Centre (PMC) for Students with Disabilities to complete the necessary *letters of accommodation*. After registering with the PMC, please discuss your needs with the Instructor at least two weeks prior to the midterm exam. For this course, the deadline for submission of completed forms to the PMC is stated in the 10/11 calendar.

**Course Outline:**

**Week 1** – Review of linear algebra, vector spaces, spanning and bases sets, subspaces, affine transformations, Laplace Transforms, state space formulation

**Week 2** – Modelling of electrical, mechanical systems as systems of linear differential equations

**Week 3** – Review of 1<sup>st</sup> and 2<sup>nd</sup> order dynamics, time and frequency response, examples

**Week 4** – Solutions of state space equations, Eigen decomposition and analysis of solutions

**Week 5** – The Z-transform, matrix difference equations, discrete-time simulation of systems, frequency response in the Z-domain

**Week 6** – Transformation to canonical forms (diagonal, observer companion, and controller companion forms), and properties/realizations of these forms

**Week 7** – Controllability and observability, concepts, tests for, and realizations

**Week 8** – Introduction to stability analysis and Lyapunov's second method with applications to linear systems and adaptive control

**Week 9** – State feedback control, specification and computation of feedback gains, deadbeat control

**Week 10** – Introduction to optimal control and the linear quadratic regulator

**Week 11** – State estimation, the linear observer, observer/controller combination

**Weeks 12-13** – Special topics: Kalman filtering, linear quadratic Gaussian controller, sliding mode controllers, nonlinear systems, as time permits

**Note:** Order of presentation of the above topics and emphasis on specific topics may change depending on the background and interests of the class.