CHE 494-561 Advanced Process Control
Spring Semester 2012
http://myasucourses.asu.edu

Instructor: D. E. Rivera, ERC-275, daniel.rivera@asu.edu, phone: (480) 965-9476

Prerequisites: Undergraduate control course or equivalent; prior exposure to MATLAB. Familiarity with SIMULINK is helpful but not required. Knowledge of basic linear algebra and complex number arithmetic is desirable.

Office Hours: 11:00 a.m. – 12 noon MW (tentative). Other times by appointment.

Course Grading:	494	561
Midterm Exam(s)	30%	30%
Homework (6-8 problem sets; failure to turn in more than one problem set will result in 0% credit for the entire category)	40%	40%
Final Design Assignment	30%	
Final Project Report + Presentation		30%

Please note:

- Letter grades will be given at the discretion of the instructor based on overall class performance and (in some instances) individual student behavior. Class performance will be periodically reviewed and discussed by the instructor.

- CHE 561 students will be required to perform additional work in midterm exams and homework sets beyond that required of ChE 494 students. CHE 561 students will work on an individually-assigned final project and presentation, while ChE 494 students will have a common final design assignment.

- Academic dishonesty (i.e., cheating) will not be tolerated in this course. Students engaged in any level of academic dishonesty will be referred to the Dean's office for disciplinary action. A signed statement of academic integrity will be required from every student.

- Extensive use will be made of the course's ***myASU*** web site for distributing notes, homework sets and solutions, and other course materials. This includes drafts of *Control Methods for Process Applications,* a monograph/text in preparation by the instructor.

- Students must have access to a recent version of Matlab with Simulink with the Control System, Signal Processing, and Model Predictive Control Toolboxes.

Textbooks:

Recommended:

Morari, M. and E. Zafiriou. *Robust Process Control*, Prentice-Hall, 1987 (ISBN 0-13-782153-0).

Ogunnaike, B.A. and W.H. Ray, 1994, *Process Dynamics, Modeling, and Control*, Oxford University Press, ISBN 0-19-509119-1.

Seborg, D.E., T.E. Edgar, and D.A. Mellichamp, *Process Dynamics and Control*, 1989, Wiley, ISBN 0-471-86389-0 (or 2nd Edition, 2004, ISBN 0-471-00077-9).

Skogestad S. and I. Postlewaithe, *Multivariable Feedback Control: Analysis and Design* Wiley, 2005, (ISBN 0-471-01168-8).

We will be making extensive use of the Morari-Zafiriou text, which can be downloaded for free from the CACHE Virtual Process Control book (http://www.cse.sc.edu/~gatzke/cache/). You will also need access to one solid undergraduate process control textbook (either the text by Ogunnaike-Ray or one of the three SEM editions). The book by Skogestad and Postlewaithe may be helpful if you plan to do research in the field of advanced control.

Additional References (all available on reserve from Noble Library):

Bequette, B.W. *Process Dynamics: Modeling, Analysis, and Simulation*. Prentice-Hall, 1998, ISBN 0-13-206889-3.

Prett D.M. and C.E. García, *Fundamental Process Control*, Butterworths, 1988.

Åström and Wittenmark, *Computer-Controlled Systems: Theory and Design*, 3rd Edition, 1997, Prentice-Hall, ISBN 0-13-314899-8 (2nd edition is also helpful)

Ljung, L. *System Identification: Theory for the User*, 2nd Edition, 1999, (ISBN 0-13-656695).

Special dates:

March 19 - 23 (Spring Break – no classes)
April 17 and 19: ChE 561 Final Project Presentations
Tuesday, May 1 (Final exam period; 9:50 – 11:40 a.m.). Final project and design assignment reports will be due by noon on that day.

Note:

The course midterm exam will likely be held in mid- to late March. I reserve the right to give two midterms rather than only one (in which case there would be a midterm exam prior to spring break). The exact date(s) will be announced with sufficient notice (at least two weeks).

CHE 494-561 Course Outline

I. Modeling and Systems Overview *(1.5 weeks)*

A. Review of dynamic modeling via conservation and accounting principles
B. Linearization and state-space model representation
C. Solution of diff eqns via Laplace transforms; transfer functions and frequency response;

II. Analysis and design of analog SISO closed-loop systems *(4 weeks)*

A. Objectives of feedback control; H_2, H_infinity, and mu optimality criteria
B. Formal Internal Model Control design procedure for continuous-time systems.
C. Extensions to multi-degree-of-freedom and feedforward control,
D. IMC design using low-order models and relationships to PID control.

VII. Analysis and design of digital SISO closed-loop systems *(3 weeks)*

A. Representation of discrete-time systems via *z*-transforms.
B. Performance and robustness of digital control systems; classical techniques
C. Internal Model Control design procedure for discrete systems

IV. Multi-input, multi-output (MIMO) systems *(2 weeks)*

A. MIMO Control Fundamentals.
B. Decoupler design and analysis.
C. IMC design procedure for MIMO plants with delay.

V. Model Predictive Control *(3 weeks)*

A. Moving horizon philosophy and state-space formulation of MPC
B. Unconstrained 2-norm MPC and constrained MPC via Quadratic Programming
C. MPC implementation aspects