Process Dynamics and Control in Design
University of Iowa CBE:4105

Instructor Information:

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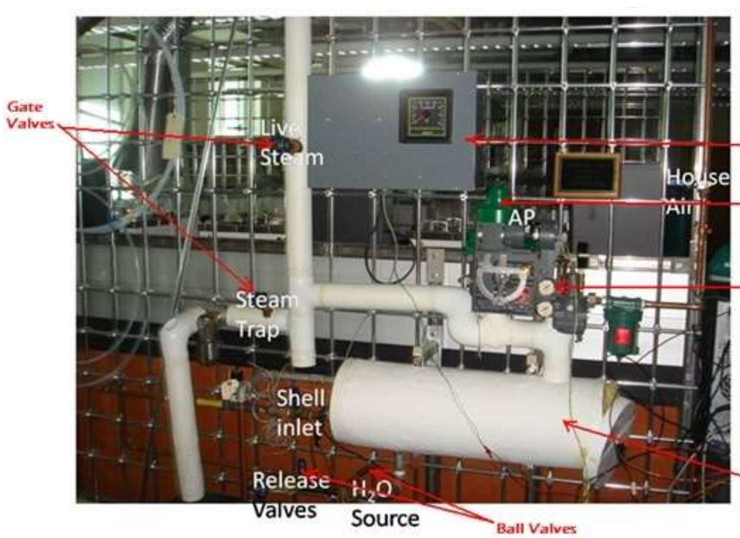
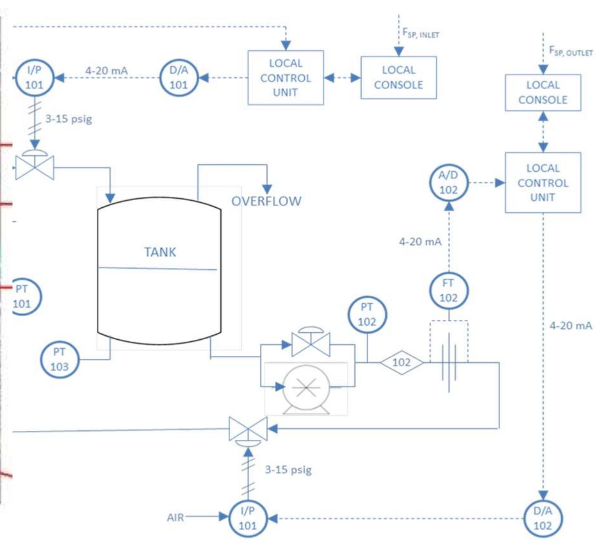
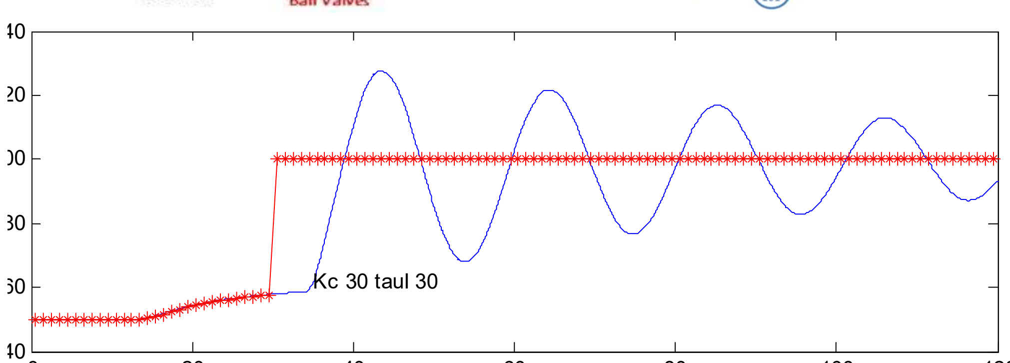
Part-time TA: Carson Hemphill carson-hemphill@uiowa.edu

Office hours to be determined and posted on ICON website.

Course Description: This senior level course, with the fond nickname “turning valves with computers” is designed to enable the synthesis of chemical engineering concepts in the understanding of practical chemical processes. Students will evaluate the behavior of real processes beyond idealized steady-state models. Students will learn how to determine system behavior under a variety of conditions. This knowledge base will ultimately enable engineers to predict process performance in response to changing conditions. Skills developed in this course will enable students to develop a fundamental understanding of process dynamics and feedback control. This understanding ultimately will enable the students to function as industrial process engineers.







TEXT:
Chemical and Bio-Process Control, Fourth edition
James B. Riggs and M. Nazmul Karim
2016 Ferret Publishing, Lubbock Texas

Supporting Texts:

Process Dynamics and Control 3rd Edition, by Dale E. Seborg and additional authors, Wiley 2010

Introduction to Analytical Methods with MATLAB for Engineers and Scientists. By William Bober. CRC Press, 2014.

Addtional Resources can be found on the course Icon page:
http://icon.uiowa.edu/

Course Components:

Course activities will include in-class problem solving, quizzes, homework, laboratory assignments, a discussion section, and design-based problems. Material covered will include theory and application of process dynamics to the design of chemical process control systems; mathematical models of unit operations, transfer functions, feedback and feed-forward control, stability, instrumentation, digital control systems; computer methods, including simulation and commercial software use. Students will be tested on this material.

Active class participation is encouraged. Through **in-class problem solving**, students will be increasing skill and fundamental understanding of process control concepts.

Quizzes will help the students reinforce strengths and identify areas for further study.

There will be two in-class exams comprised of analytical problems based on material covered since the last exam. The goals of the exams are to determine and demonstrate ability to perform good engineering analysis. These exams will help students grow in confidence regarding their skills for analytical thinking with a minimal amount of supporting material. The course will also include a comprehensive final exam. Exams typically include both closed-book and open-book sections.

The course includes training in solving differential equations and in using process-based equations using modern languages. Students will use MATLAB, Visual Basic or Excel to complete the numerical and programming assignments. Students are expected to be proficient at specifying and solving systems of differential equations in the time domain, and using transfer functions. Programming and excel homework assignments regarding numerical solution of ODEs must be done in order and assignments cannot be skipped. Credit is only given when all of them are satisfactorily completed. They may not be turned in late without instructor permission. Therefore, not completing the first assignment will lead to a zero in this entire area of numerical solutions to ODEs.

This course also includes the **process control laboratory**. The laboratory will consist of operating and evaluating PID flow, level, and temperature control systems that operate using DeltaV and Labview software/hardware systems. The laboratory equipment will help students become familiar with control hardware and practical applications in control. Students will perform the labs in groups.

Homework will be assigned on a weekly basis. The TAs will grade the homework and laboratory assignments. Late assignments will incur a 10% grade deduction for each day the assignment is past due.

Scheduling of Labs

The scheduled lab time for this course is 1:30-4:20 on Tuesdays and Thursdays. There will be four labs to complete and each is associated with a written or oral lab report. While students are in the lab, the teaching assistant is to be present. Therefore, all labs must be performed during prearranged times. For students with absolute conflicts during the 1:30-4:20 time period, **reasonable accommodations** will be made, subject to the schedule constraints of the teaching assistant. That said, we expect that students will also make reasonable accommodations in their schedules. It is the responsibility of the students to complete the labs, and scheduling conflicts will not be accepted as an excuse for incomplete or late lab reports.

Lab reports will be returned with comments and (for at least some of the labs) lab groups are expected to revise the lab reports and turn them in a 2nd time. Addressing critical comments effectively is an important skill that is part of the professionalism expected by engineers.

Students are encouraged to consult with the Hanson Center for Technical Communication for tutoring on improving writing style and clarity.

Course Schedule

The midterm exams are scheduled for in class on Tuesday Sept 26, and Thursday Nov 2. Students are responsible for monitoring the course calendar for any deadlines.

Grading Policy

Professor Stanier and the TAs will grade all exams. While specific portions of the course are graded on a curve, other portions are graded on an absolute scale. Students should treat all sections of the course as graded on an absolute scale – in other words, students should not count on low performance as being "OK because it will get curved." Similarly, students achieving high marks should not worry about them being discounted due to a curve.

For example, for homework and attendance, the following scale will be used:
> 90 = A 77-89 = B 63-76 = C 45-62 = D

Course Component		Weight in Course Grade
Quizzes and Exams	**43%**	
Individual Quizzes		8%
In class exams (2)		20%
Final exam		15%
Lab Component of Class	**25%**	
Lab Attendance, Prelabs, and Lab Reports		20%
Professionalism, assessed by (1) quality, readability, and thoroughness of revisions of lab reports; and (2) distribution of effort across all lab group members, turning in of individual effort assessments on time, quality of individual effort assessments		5%
Individual Assignments	**22%**	
Problem Sets		12%
Numerical/ODE/Programming Assignments		10%
Participation and Attendance and Group Quizzes	**10%**	
Group Quizzes		5%
Lecture attendance		5%

Students meeting the following criteria will be exempted from the final exam:

Overall course grade of A- A or A+ going into final
Average of 70% or higher on any quizzes after in class exam 2
Attendance of all labs and no issues with lab reports, prelabs, or lab safety
Satisfactory completion of all numerical/ODE/programming assignments
Satisfactory completion of any problem sets that cover material after exam 2

Course Learning Goals

1. By the end of the course the student will be able to construct control block diagrams (i.e. control logic diagrams) for everyday and conventional examples of controllable systems.
2. By the end of the course the student will be familiar with process control hardware, how it integrates with the process, and how it is represented in P&ID diagrams.
3. By the end of the course the student will be able to write time-dependent differential equations which describe real operations for single input/single output (SISO) systems and for multiple input/multiple output (MIMO) systems.
4. By the end of the course, the student will be able to use Laplace transforms to evaluate process dynamics and to solve differential equations
5. By the end of the course the student will be able to use and define transfer functions for dynamic systems.
6. By the end of the course the student will be able to mathematically model time-dependent real processes.
7. By the end of the course the student will be able to demonstrate understanding of the linkages between process, dynamic behavior of process inputs and outputs, and idealized transfer functions.
8. By the end of the course the student will be able to analyze real or modeled process behavior for identification and design of effective feedback control strategies, including the use of characteristic equations and specifying the mode of PID control
9. By the end of the course the student will be able to utilize practical and mathematical tools (e.g. MATLAB, Simulink, DeltaV, and Labview)
10. By the end of the course the student will demonstrate skills necessary to tune, and troubleshoot basic feedback control strategies to SISO systems.
11. By the end of the course the student will demonstrate professional accountability for their dynamic modeling and control strategy recommendations.
12. By the end of the course the student will be able to recommend improvements to systems involving cascade, ratio and feedforward control

TOPIC COVERAGE

- A detailed schedule of due dates and exam dates will be posted on the course ICON website.

- Topics will be covered in the following order with the approximate number of 75 minute class sessions devoted indicated in parentheses – the Chapter from Riggs and Karim 2nd Ed. will be listed

Topic	Number of Class Sessions	Textbook Chapters & Other Notes
Overview and introduction	1	
Process Control in everyday situations / Generalized Control Systems / Introduction to Control Logic Diagrams / Definitions	1	textbook chapter 1
P&ID Diagrams	1	textbook appendix B and handout
Control Loop Hardware, including DCS architecture, Fieldbus, 4-20 mA loops, and flow control valve sizing introduction	3	Textbook chapter 2
Dynamic modeling / setting up ODE representations of real systems	2	Textbook chapter 3; may include hands on computer lab introduction to matlab
Laplace Transforms	2	Textbook chapter 4
Transfer Functions	2	Textbook chapter 5
Dynamic Behavior of Ideal Systems	2	Textbook chapter 6; may include hands on computer lab introduction to matlab
Introduction to PID Control and Effect of Tuning Parameters on Dynamic Behavior and Stability	4	Textbook chapters 7 and 8
Tuning of PID Control Loops	2	Textbook chapter 9 – also extensive practice in lab on this topc
Troubleshooting of PID Control Systems	1	Textbook chapter 10
Cascade, Ratio and Feedforward Control	2	Textbook chapter 12
Enhancements and implementation issues for PID Control (Inferential Control; controller scheduling; windup; split-range and other topics)	2	Textbook chapters 13-14
Introduction to MIMO Systems and Introduction to Model Predictive Control (MPC)	1	Textbook sections 15.1, 15.2, 16.1, 16.2
In class exams	2	
Available class sessions for review or catching up if behind	2	
TOTAL	30	

Notes on the process control lab:

The lab requires

1. Attendance for the full period of the experiment, unless you have prior permission from the instructor or TA
2. The lab also requires the following basic safety precautions
    a. Closed toed shoes and covered legs
    b. No food or drink in the lab
    c. Safety glasses at all times

The lab includes a participation grade assessed by the TA.This is based on being THERE, being prepared, and being engaged. At the instructor's request, the TA deducts points for students who disengage from the lab to check cell phones or other digital devices, or who are not participating for other reasons.

If food is brought into the lab, or if the TA sees a student without safety glasses.

- First occurrence: warning
- Second occurrence: will be asked to leave the lab and will receive zero for that lab
- Third occurrence: F for the entire lab component of the course (28% of the grade)

Based on overall judgement of the instructor and TA, up to ten students will be selected for individual practical exams by Dr. Stanier with their laboratory apparatus. Lab participation and attendance, peer assessments, attitude, and participation in the revision process will be used to select students. Students will be asked to operate their system in both manual and automatic control modes, change setpoints, and change control parameters – while explaining the relevant hardware and software components. Scoring will be on a 1-5 scale.

- 5 excellent system knowledge and ability to operate: overall lab grade will receive a 5 point bonus, up to a limit of 95
- 4 average system knowledge and ability to operate: overall lab grade will receive a 5 point bonus, up to a limit of 85
- 3 system knowledge and/or ability to operate needs improvement: overall lab grade will remain unchanged if below 60. Will receive a 10 point deduction (down to a limit of 60) if above 60
- 2 limited system knowledge and/or limited ability to operate: overall lab grade will remain unchanged if below 50. Will receive a 15 point deduction (down to a limit of 50)
- 1 very limited system knowledge and/or very limited ability to operate: overall lab grade will remain unchanged if below 40. Will receive a 20 point deduction (down to a limit of 40) if above 40.

Guidelines on Academic Misconduct and Other Matters

- Cheating on hour or final exams will result in an F in the course. Examples of cheating include but are not limited to looking at your neighbor's exam papers, discussing problems during an exam, or copying answers from another exam paper.
- Cheating on a quiz will result in a zero for the quiz portion of the class (e.g. a zero for all quizzes in the class). Examples of cheating include but are not limited to looking at your neighbor's quiz papers, discussing problems during a quiz, or copying answers from another exam paper.
- Plagarism on a lab report may result in penalties up to 0 in the quiz portion of the class (e.g. a zero for all lab reports) for all members in the lab group. Lesser penalties may be used at the instructor discretion.

- Acceptable collaboration on homework is defined as working on problems together. However, each student should write out the final calculation for themselves, and calculate any quantities using their own calculator or spreadsheet. This includes the visual basic simulator – while working together to get the basic idea of a VB simulator problem, the final parameter adjustments and graphs should be done individually. Otherwise, the person sitting at the computer may learn the most.
- Acceptible collaboration on MATLAB is similar. It is extremely useful to sit at neighboring computers and to talk to one another about lines of code, syntax, errors, and results, each student should create, run, edit, and comment their own code on their own college computing account. Working on a matlab program "together" (with one person typing and another looking over their shoulder) and then turning in two copies of the same program is not acceptable because the learning and preparation for quizzes and exams is not equal.
- Incidents of academic misconduct will be referred to the Dean's office and may result in additional penalties up to and including dismissal from the University

This course is given by the College of Engineering. This means that class policies on matters such as requirements, grading, and sanctions for academic dishonesty are governed by the College of Engineering. Students wishing to add or drop this course after the official deadline must receive the approval of the Dean of the College of Engineering.

Attendance and federal financial aid.

Short version. Non-attendance of class, especially in the first 10 days, can lead to requirements for prompt repayment of federal financial aid.

Long version, from the office of the Provost:

Federal financial aid regulations require that The University of Iowa take additional steps during the semester to verify that students receiving federal financial aid are active in their courses. We want to stress that The University of Iowa does not have an attendance policy and we do not anticipate creating an attendance policy. However, to keep our students eligible to receive federal Title IV financial aid, the University must comply with the new regulations. We need your help to do so. Specifically, we are asking that all faculty and instructors respond to requests from the UI Registrar and UI Office of Student Financial Aid for specific information about the academic activity of their students.

The UI Office of Student Financial Aid may be able to reduce the financial liability of individual students by thousands of dollars based on your verification of academic activity (as defined below). During the Spring 2011 review, students for whom academic activity could not be verified were required to repay an average of $4700 in federal financial aid. For many students, this debt may be insurmountable and put an end to their academic careers. Your assistance is extremely important.

Each semester and for each class, the UI Registrar asks faculty and instructors to verify after the tenth day of the semester that a student attended class or participated in an academic activity (as defined by the U.S. Department of Education) on any day since the beginning of the class. The University REQUIRES 100% completion of the tenth day attendance report by faculty and instructors in order to comply with federal financial aid regulations. The UI Registrar also asks faculty and instructors to verify academic activity at midterm each semester. We request that all faculty and instructors complete these verification forms for every class.

If a student receiving federal financial aid receives ALL grades of I, F, U or N, during any semester, the UI Office of Student Financial Aid may contact you after the end of the semester to obtain a last date of academic activity. This date will determine whether or not a student has to repay a portion of his or her federal financial aid (grants and loans). The UI Office of Student Financial Aid is required by federal law to complete this review and adjust financial aid within 30 days of the end of the semester. We request that all faculty and instructors watch for an email of this nature and respond by the deadline provided in the email.