Spring 2020

CHE 489-002: Process Dynamics and Control

Richard T. Cimino

1. **ChE 489 - Process Dynamics and Control**
2. **Credits and contact hours:** 4-0-3 (4 lecture hr/wk - 0 lab hr/wk - 3 course credits)
3. **Course Coordinator:** Dr. Sagnik Basuray
4. **Course Instructor:** Dr. Richard T. Cimino
5. **Textbook:** Process Dynamics and Control 4th Edition by Seborg, Edgar, Mellichamp and Doyle, John Wiley & Sons, Inc. ISBN: 978-1-119-28591-5
6. **Specific course information**
    a. **Description:** This course is an introduction to chemical process dynamics and control. Topics include analysis of the dynamics of open-loop systems, the design of control systems, and the dynamics of closed-loop systems. Control techniques and methodologies, used by practicing chemical engineers, are emphasized.
    b. **Prerequisites:** ChE 349; ChE 365
    c. **Required, Elective, or Selective Elective** - Required
7. **Specific goals for the course**
    a. A student should be able to:
        1. Model chemical engineering processes and analyze/predict their dynamics both for open- (without control) and closed-loop (with control) cases.
        2. Develop control strategies and select the most appropriate input to manipulate, and to tune controllers to meet/achieve specified process objectives.
        3. Work effectively in problem-solving teams and assess the performance of their teammates and themselves on the group efforts.
    b. This course explicitly addresses the following ABET student outcomes:
        i. 1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
        ii. 2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
        iii. 5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
8. **Topics**
    1. Theoretical Models of Chemical Processes
    2. Laplace Transforms
    3. Transfer Function Models
    4. Dynamic Behavior of First and Second Order Systems
    5. Dynamic Behavior of Complex Systems
    6. Feedback Controllers and Controller Instrumentation
    7. Dynamic Behavior and Stability of Closed-Loop Systems
    8. PID Controller Design and Stability
    9. Feedforward and Ratio Control

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Instructor: Dr. Richard T. Cimino, Senior Lecturer
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Class: Monday, Thursday 10 AM -12:05 PM Room: Kupfrian 203
Office Hours: By arrangement only - please sign up online at https://drcimino.youcanbook.me

Course Description and Requirements

This course is an introduction to chemical process dynamics and control. Topics include analysis of the dynamics of open-loop systems, the design of control systems, and the dynamics of closed-loop systems. Control techniques and methodologies, used by practicing chemical engineers, are emphasized.
Pre-Requisites: ChE 349; ChE 365

Course Objectives

Taking this course, a motivated student will learn to:

- Model chemical engineering processes and analyze/predict their dynamics both for open- (without control) and closed-loop (with control) cases.
- Develop control strategies and select the most appropriate input to manipulate, and to tune controllers to meet/achieve specified process objectives.
- Work effectively in problem-solving teams and assess the performance of their teammates and themselves on the group efforts.

Learning Materials

Textbook Required: Process Dynamics and Control (4th Edition) by Seborg, Edgar, Mellichamp and Doyle, John Wiley & Sons, Inc. ISBN: 978-1-119-28591-5

Other Learning Material: The textbook is the main source for preparing for classes and reading the textbook before each class is necessary. Additional materials will be posted on Canvas.
Calculator: A high-end calculator (TI-83, TI-84 or TI-84SE) is required for solving exam problems.
Computer: A portable laptop computer running MATLAB Simulink is strongly recommended for in-class activities and homework assignments.
Required Software: In this course you will learn to model dynamic systems with MATLAB and Simulink. You are required to have a working version installed on your computer.

Course Outline

	Date	**Topic and Reading** (preliminary, subject to minor changes)
1.	Jan. 23	Intro to PD & C. Ch. 1.1-6
2.	Jan. 27-30	Theoretical Models of Chemical Processes. Ch. 2.1-5
3.	Feb. 3-6	Laplace Transforms. Ch. 3.1-5
4.	Feb. 10-13	Transfer Function Models. Ch. 4.1-3
5.	Feb. 17-20	TF models cont'd., Exam 1. Ch. 1-4
6.	Feb. 24-27	Dynamics of 1st Order Systems. Ch. 5.1-3
7.	Mar. 2-5	Dynamics of 2nd Order Systems. Ch. 5.4
8.	Mar. 9-12	Dynamics of more complicated systems. Ch. 6.1-6
9.	Mar. 23-26	Exam 2, Ch.5-6. Control instrumentation. Ch. 8-9
10.	Mar. 30- Apr.2	Steady State Feedforward Controllers. Ch. 15.3
11.	Apr. 6-9	Feedback controllers and Loop Dynamics (project assigned) Ch. 11.1-3
12.	Apr. 13-16	Loop Dynamics cont'd. Stability of Loops. Ch. 11.4-5
13.	Apr. 20-23	Stability cont'd.
14.	Apr. 27-30	Exam 3. Ch. 11, 15.3, FF/FB Control Ch. 15.4
15.	May. 4	Final Review (project due).

Assessment and Grading

Exams: There will be three midterm exams (2 hours long) and one final exam (2.5 hours long). All exams will be closed book, however a handwritten sheet (double-sided, letter size) with materials used to prepare for midterm exams will be allowed. For the final exam two sheets are allowed. Shared or copied preparation sheets, as well as use of any electronic materials will be considered as a violation of academic integrity.

Project: There will be one team project requiring computer programming and a written report. Details of the assignment will be given well in advance of the due date. You will be allowed to choose your teammates (teams may not exceed 4 members). If a student's name appears on the project report, it certifies that they have participated in the project.

Peer Evaluation: You will use the Comprehensive Assessment of Team Effectiveness (CATME, `www.catme.org`) to evaluate the teaming behaviors of yourself and your teammates. These evaluations will be incorporated into the assignment of final project grades.

Upon evaluation, each student is assigned a multiplier related to how you and your teammates rated your performance. Your multiplier ranges from 0 to 1.05 and is related to the team's average evaluation score. If your multiplier $= 1 \Rightarrow$, your rating is the same as the team average; $< 1 \Rightarrow$ your rating is less than the team average; $> 1 \Rightarrow$ your rating is greater than the team average. Your final team project score is then weighted by this multiplier:

e.g. 90% total Team project score $\times$ (1.05) = 94.5%

Conflict Resolution: Consult with your instructor immediately if a conflict arises that cannot be worked through by the team.

Firing: If a team member refuses to cooperate, their name should not be included on the report. If the non-cooperation continues, the team should meet with the instructor so that the problem can be resolved, if possible. If no resolution is achieved the cooperating team members may notify the uncooperative team member in writing (by email, cc the instructor) that they are in danger of being fired. If there is no subsequent improvement, the team should notify the uncooperative team member in writing (by email, cc the instructor) that they are no longer with the team.

Quitting: Students who are consistently doing all the work for their team may issue a warning (by email, cc the instructor) that they will quit unless they start getting cooperation and a second memo (by email, cc the instructor) quitting the team if things do not improve.

Students who are fired or quit must meet with the instructor immediately, or they will get zeros for the project. Students who quit will be allowed to join another team (cannot exceed 4 members) or to work alone, by their own choice. If a student decides to work alone, they may not later ask to join a team. Students who are fired may work together (if there is more than one at any time). Otherwise, they must work alone.

Homework: Homework assignments will be posted weekly on Canvas. Homework assignments are due one week after they are assigned, and must be submitted electronically on Canvas. No late homework will be accepted. Students may complete and submit homework either individually or as a pair.

Quizzes: Regular quizzes will be given based on the course material, including both concepts and problems. The quizzes will be announced in advance. No make-up quizzes will be allowed. All quizzes will be closed book with no material allowed. The quizzes will take place at the beginning of the class, so being on time is strongly encouraged.

Homework and quizzes are evaluated using the following scale:
✓+ The solution is 100% correct and presented in a thorough, logical fashion.

✓Solutions contain some errors but present a reasonable attempt at solving all problems.

Each homework or quiz that receives at least a ✓will count as full credit (100%) towards your homework and quiz total.

✓− Solutions contain multiple substantial conceptual errors, and/or give only a cursory attempt at solving some problems. Each homework or quiz that receives a ✓− will count as half credit (50%) towards your homework and quiz total.

Zero - No submission. A zero is equivalent to three ✓− grades, and is counted as a zero (0%) towards your homework and quiz total.

Final Course Grades: Your grade for the class will be determined from your homework & quiz total plus your project and exam grades, as follows:

For students who have more ✓+ scores than ✓− scores, the grade will be calculated by:

Homework & Quizzes	20%
Project (team)	15%
Lowest Midterm Score	10%
Other Midterms (2)	30%
Final Exam	25%
	100%

For students who have at least as many ✓− scores as ✓+ scores, the grade will be calculated by:

Homework & Quizzes	15%
Project (team)	15%
Midterms (3)	45%
Final Exam	25%
	100%

Letter grades corresponding to your numerical score will be assigned according to the following:

Percent	Grades
90.0% or higher	A
above class mean	B+
class mean	B
transition	B/C+
transition	C+/C
below 55.0%	D/F

Grading: This course has both curved and absolute elements. The requirement for an A in this class is 90.0% or above. Students with less than 55.0% will receive an F. Grades of D are only very sparingly awarded, based on effort. Students whose grade average is the class mean will receive a B. Students whose grades cluster between the mean and 90% will receive a B+. Students whose grades cluster between the mean and 55% will receive a B, C+ or C based upon the natural breaks in the sub-clusters, with the highest (nearest the mean) receiving a B, the next highest a C+, and the lowest a C.

Important Dates

- Midterm exam #1: February 20, 2020
- Midterm exam #2: March 23, 2020
- Midterm exam #3: April 27, 2020
- Final exam: between May 8 and 14, 2020
- Withdraw Deadline: April 6, 2020

Policies

NJIT Honor Code: The NJIT Honor Code will be upheld and any violations will be brought to the immediate attention of the Dean of Students.
Special Needs: If you need accommodations due to a disability please contact Chantonette Lyles, Associate Director of Disability Support Services, Fenster Hall Room 260 to discuss your specific needs. A Letter of Accommodation Eligibility from the Disability Support Services office authorizing your accommodations will be required.

Lectures

- Attendance is strongly recommended. Missing class will have consequences for preparation for quizzes and exams.
- Class starts at 10:00 AM, and students must be in class by that time. Being late to class may have consequences for the grade, since several of the classes will start with quizzes.
- Electronic devices other than calculators (laptops, tablets, cell-phones etc.) are not permitted during the classes. No audio or video recording is allowed.
- Cellphones should be turned off during both lectures and exams and not allowed under any circumstances.
- Laptops will be permitted only if necessary for class activities.
- No distracting eating any time during the classes.

Course materials, office hours and correspondence

- The course Canvas page is the main platform for delivering information about the course. All relevant course materials and assignments will be posted on Canvas, so a student should check it regularly.
- The students have to upload a professional-looking head shot for their Canvas profile.
- The students are strongly encouraged to attend Office Hours. Long questions, which require derivations will be discussed only during the Office Hours and will not be answered by email. Questions regarding grades can be discussed only during the Office Hours.
- E-mail and Canvas correspondence is intended only for quick questions. Questions which require a detailed discussion should be discussed in person during the Office Hours.
- All correspondence should be conducted in a professional style, using formal English.
- To help assure quick response to your emails, please add "ChE489" in the subject of your emails.
- The instructor reserves the right not to respond to emails if the email does not have a greeting or a signature.

Exams, Quizzes, Homeworks and Grades

- A letter grade is based on the final score, calculated using an Excel spreadsheet in accordance with the Tables given in this syllabus. The assigned letter grade is final and cannot be negotiated.
- A student can dispute the exam scores within a week after the announcement of the score. Exam scores can be disputed during Office Hours, not during class time or via email.
- The graded exams must be returned within a week to be saved for the department course assessment initiative. If a student does not return the exam, the grade for this exam is zeroed.
- Students will get zero for not coming to quizzes, exams, or any other course activity. If students miss an exam due to extreme circumstances (such as a medical problem), they need to bring proof of the circumstance to the Dean of Student's office. Only in the case of official approval from the Dean of Student's office, may a make-up be given at the discretion of the instructor.
- A student must show as many details as possible when solving a problem during an exam or a quiz. Not showing the work will cause losing points even if the final answer is correct.
- Partial credit can be given for solving exam problems.
- No partial credit will be given if there is not enough details to follow.

- The final answer should be always evaluated with respect to its reasonability. No partial credit will be given if the final answer is wrong and unreasonable, and it is not stated.
- Each quiz or homework is worth an equal amount of the overall homework & quiz grade.
- If a student misses a quiz or homework submission due to a legitimate reason (absence approved by the Dean of Students), this item is excluded from the calculation, and the weights of the remaining items are scaled proportionally.
- Student handwriting must be legible in order to receive points.
- A student coming to dispute a grade has to bring completed work. No discussion of grades will be held without completed work.

Homework Format

- Homework involving calculations must be done on Engineering paper.
- All homework involving MATLAB calculations must be presented with original MATLAB files.
- All homework submissions must be through Canvas. I will not accept emailed or hard-copy homework.
- Headers - The top of each sheet of a homework assignment must contain the following printed information from left to right:

Name(s)	Course & Section No.	Date Due	Page number/total pages

- Writing Mechanics - All homework should be carefully written using proper English.
- Calculations - All homework calculations should be consistent with the following.
  - Include complete calculations for every calculation presented to demonstrate how results were obtained.
  - Include all units for each term in each equation. The units must balance.
  - Use the appropriate number of significant figures (often two or three) for all results (but use at least two extra significant figures in calculations).
  - Clearly indicate the final solution by boxing it in with a rectangle.
- Problem Order - Problems should clearly labeled, and presented in the order assigned (one, two, three, etc.).
- Problem Essentials - Problem solutions should include the following items in order.
  - Homework problem number listed at the beginning of the problem.
  - Brief problem statement. Provide bullet points of key aspects of the problem if it is longer than a few sentences.
  - The required information - the information or solution that we are looking for.
  - A straight-edge or carefully drawn diagram(s) that clearly illustrates the problem. Optional, but often needed.
  - The boxed solution of the problem including all required steps and calculations.