Fall 2020

# CHE 489-001: Process Dynamics and Control

Richard Cimino

1. **ChE 489 - Process Dynamics and Control**
2. **Credits and contact hours:** 3-0-1 (3 lecture hr/wk - 1 lab hr/wk - 3 course credits)
3. **Course Coordinators:** Dr. Sagnik Basuray, Dr. Richard T. Cimino
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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# Fall 2020

**Instructor:** Dr. Richard T. Cimino, Senior Lecturer
**Office:** 387 Tiernan Hall, Phone: 973-596-5729, E-mail: cimino@njit.edu
**Class:** Tuesday 9-11:05 AM, Friday 8:10-10:15 AM, synchronous online
**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.
**Required Hardware:** A working computer equipped with a working webcam and a working microphone. Note - tablet devices are not acceptable for this course.

**Required Software:** Google Chrome browser or Firefox browser; Respondus Lockdown Browser, Google docs, sheets, drive.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.

**Internet Access:**You must have a reliable internet connection for your device.

**Note: If you do not meet all of these requirements you cannot take the course online and must instead take it in person at another time.**

## Course Outline

| | **Date** | **Topic and Reading** (preliminary, subject to minor changes) |
|---|---|---|
| 1. | 9/1-4 | Ch. 1.1-5, Ch. 2.1-2 |
| 2. | 9/11 (Fri.) | Ch. 2.3-4 |
| 3. | 9/15-18 | Ch. 3.1-5 |
| 4. | 9/22-25 | Ch. 4.1, Exam Review |
| 5. | 9/29-10/2 | Exam 1, Ch. 4.2 |
| 6. | 10/6-9 | Ch. 4.3, Ch. 5.1-2 |
| 7. | 10/13-16 | Ch. 5.1-2, Ch. 5.4 |
| 8. | 10/20-23 | Ch. 5.4, Ch. 6.1-2 |
| 9. | 10/27-30 | Ch. 6.3, Exam Review |
| 10. | 11/3-6 | Ch. Exam 2, Ch. 9 |
| 11. | 11/10-13 | Ch. 15.3, Ch. 8 |
| 12. | 11/17-20 | Ch. 11.1-2 |
| 13. | 11/25 (Wed.) | Simulink |
| 14. | 12/1-4 | Exam 3. Ch. 11.3-4 |
| 15. | 12/8 (Tues.) | Project Work Period, Final Review |

## Assessment and Grading

**Exams:** There will be two midterm exams (125 min long) and one final exam (180 min long). All exams will be open book, and a handwritten sheet (double-sided, letter size) with materials used to prepare for exams will be allowed for the midterm exams. Two sheets will be allowed for the final exam. Shared or copied preparation sheets, as well as use of any electronic materials including e-books will be considered as a violation of academic integrity.

**In-class activities:** We will be devoting a considerable amount of in-class time to active learning activities. Participation in these activities is vital to your success in the course, and is REALLY good practice for the exams! You will submit your activity work for pass/fail credit (submission of a reasonable attempt = pass, anything else is a fail). You will be working in small groups to do these activities, but will get an individual grade for your individual submission.

**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 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 score is then weighted by this multiplier:

e.g. 90% total Team 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 on an assignment, their name should not be included on the final deliverable. 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 on the next assignment, 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 remaining team assignments. Students who quit will be allowed to join another team (cannot exceed 5 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 must submit homework individually.

**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. (100%)

✓Solutions contain some errors but present a reasonable attempt at solving all problems. (90%)

✓− 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 earn partial credit(50-70%) towards your homework and quiz total, depending on the quality of the work.

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% |
| In-class activities | 5% |
| Lower Midterm Score | 15% |
| Higher Midterm Score | 25% |
| Final Exam | 20% |
| | 100% |

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

| | |
|---|---|
| Homework & Quizzes | 20% |
| Project (team) | 15% |
| In-class activities | 5% |
| Lower Midterm Score | 20% |
| Higher Midterm Score | 20% |
| Final Exam | 20% |
| | 100% |

Final course grades will be assigned according to the following rubric:

| |
|---|
| $90\% \leq$ A $\leq 100\%$ |
| $85\% \leq$ B+ $\leq 89\%$ |
| $80\% \leq$ B $\leq 84\%$ |
| $75\% \leq$ C+ $\leq 79\%$ |
| $70\% \leq$ C $\leq 74\%$ |
| $60\% \leq$ D $\leq 69\%$ |
| $0\% \leq$ F $\leq 59\%$ |

## Important Dates

- Midterm exam #1: Sept. 29, 2020
- Midterm exam #2: Nov 3, 2020
- Final exam: between Dec. 14 and 18, 2020
- Withdraw Deadline: Nov. 9, 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**

- This course is a synchronous online course. This means that each lecture will take place online during the class hours. Attending the online sessions is mandatory. Failure to attend the online sessions may result in being marked as "unattended" for the course, which may negatively impact your financial aid status. Additionally, the examples discussed in the class are not necessarily from the main textbook and therefore missing a class will have consequences for your preparation for quizzes and exams.
- Students must be in the online meeting room by the class start time. Being late to class may have consequences for your final course grade, since several classes will begin with quizzes.
- No audio or video recording is allowed. All sessions will be automatically recorded for you to review at a later date.
- Cellphones should be turned off during both lectures and exams and not allowed under any circumstances.
- You must keep your webcam ON and your microphone OFF (muted) unless otherwise notified.

**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.
- Students must upload a professional-looking head shot for their Canvas profile.
- 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 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, Homework 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 only be disputed during the official Office Hours, not during class time or via email.
- 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 notify the instructor via email before the beginning of the exam, and 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 full details when solving a problem during an exam or a quiz. Not showing the work will cause the losing points even if the final answer is correct.
- Partial credit can be given for solving the exam and quiz problems, though no partial credit will be given if there are 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.
- If a student misses a quiz due to a legitimate reason (absence approved by the Dean of Students), this quiz is excluded from the quiz average calculation.
- Student handwriting must be legible in order to receive points.

**Engineering Homework Format**

- Homework involving calculations must be done using proper Engineering format, preferably on engineering paper.
- Homework involving written responses must be typed.
- All homework submissions must be submitted online as a single PDF document, and must be submitted through Canvas. I will not accept emailed homework.
- Headers - The top of each sheet of a homework assignment must contain the following printed information from left to right:

| Name | 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.