Fall 2021

CHE 210-001: Chemical Process Calculations I

Piero Armenante

Dr. P. M. Armenante
New Jersey Institute of Technology
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Chemical Process Calculations I
ChE 210

Syllabus

Term: 2021 Fall Semester

NJIT Course Title: ChE 210-002 – Chemical Process Calculations I
2 credits, 3 contact hours (2;0;1)

Class Days and Times: Monday and Wednesday, 1:00 - 2:20 pm

Classroom: Central King Building (CKB), Room 226, NJIT

Course Instructor:

Piero M. Armenante, Ph.D.
Distinguished Professor of Chemical Engineering
Master Teacher
New Jersey Institute of Technology
Otto H. York Department of Chemical and Materials Engineering
Newark, NJ 07102

Office: Tiernan Hall – Room 374
Telephone: (973) 596-3548; **Mobile: (908) 347-8734** (**preferred**)
Fax: (973) 596-8436
E-Mail Address: piero.armenante@njit.edu

Instructor's Office Hours: Monday and Wednesday, 11:45 am - 12:45 pm. Meeting room: 374 Tiernan Hall (office). Students can additionally e-mail Prof. Armenante to set up appointments outside office hours, possibly to be conducted via WebEx, i.e., online if needed.

Teaching Assistant (TA):

Ms. Hadis Gharacheh
Ph.D. Student in Chemical Engineering
Otto H. York Department of Chemical and Material Engineering
New Jersey Institute of Technology
Newark, NJ 07102-9895
Office: YCEES (York) Building – Room 334
Telephone: 973-596-5701
E-mail: hg8@njit.edu

TA's Office Hours: Tuesday and Thursday, 4:00-5:00 pm, or by appointment.
YCEES (York) Building – Room 334; or electronically via WebEx.

Computer Software Requirements:

- NJIT e-mail account, including UCID and password, to access:
  - Canvas (https://canvas.njit.edu/)
  - WebEx (https://njit.webex.com/)
- Web browser (Chrome, Firefox, Safari, etc. - Internet Explorer is not recommended)
- Adobe Acrobat (freeware)

- Other common software to complete assignments (e.g., Microsoft Word, Microsoft Excel, etc.)

Mobile Phone App Requirements:
- Office Lens (free) and/or CamScanner Apps (free)
- Cisco WebEx Meeting App (free)

Textbooks and Course Notes:
- **Textbook**: The following book is **required**:
  Elementary Principles of Chemical Processes by R.M. Felder, R.W. Rousseau, and L. G. Bullard, 4th Edition (2015). ISBN: 978-0470616291.
  - ***Remark****: Students should seriously consider buying a hard copy of the textbook instead of an e-book since exams are* ***open-book****, and computers and tablets will not be allowed to access the internet during exams*. I think that most students will eventually agree that this is a book that they want to have in their professional library.
- **Course Notes**: Armenante, P. M., 2021, *ChE 210 – Chemical Process Calculations I: Course Notes*. The *Notes* are available through Canvas and can be accessed as described below.

Availability of Course Notes, Homework Assignments, and Textbook:
- Links to the *Course Notes* and the homework assignments will be available to the students through Canvas. Students can access Canvas directly by going to https://canvas.njit.edu/ and following the instructions there
- The *Course Notes* will be posted on the internet as PDF files
- The homework assignments, homework solutions, and projects will be posted through Canvas as appropriate, depending on the material covered in that week (typically but not always on a weekly basis)
- If students experience problems and they are unable to log in or access course material, they should contact the NJIT Helpdesk at 973-596-2900
- The textbook is available in the NJIT bookstore (120 Summit Street; njit@bkstr.com; 973-596-3200; https://www.bkstr.com/njitstore/home) or from the publisher

Course Prerequisites and Corequisites:
- Prerequisites:
  - CHEM 126-General Chemistry II
  - MATH 112-Calculus II

Course Description (from the NJIT catalog): Analysis of chemical processes is introduced, emphasizing steady and unsteady-state mass and species balances. This course uses primarily chemistry and algebra to determine, for a wide variety of processes and applications, the flow and concentrations of different chemical species.

Course Purpose: ChE 210 prepares students to formulate and solve **material balances** on chemical process systems and lays the foundation for subsequent courses in thermodynamics, unit operations, kinetics, and process dynamics and control. More fundamentally, it introduces the engineering approach to problem-solving: breaking a process down into its components, establishing the relations between known and unknown process variables, assembling the information needed to solve for the unknowns, and finally obtaining the solution using appropriate computational methods.

Overall Course Objective:
- As the first true course in chemical engineering, ChE 210 introduces students to the fundamentals of chemical process analysis. In this course students will learn how to perform **material balances**, unquestionably the first and most important quantitative element in the analysis of any process.
- ChE 210, together with *ChE 240–Chemical Process Calculations II* and *ChE 260–Fluid Flow* (its companion courses dealing with energy balances and momentum balances, respectively, to be taken next semester) provides the foundations for all ChE courses that will follow. Since much of the rest of the chemical engineering curriculum is built on these three courses, failure to grasp the

principles covered in ChE 210 (as well as ChE 240 and ChE 260) will have long lasting consequences and will be very detrimental to your performance in their Junior and Senior years, not to mention your professional life.
- ChE 210 is a rigorous, conceptually simple ("mass is conserved"), but application demanding course that will require students to develop new patterns of thinking and new approaches to quantitative problem solving.

Specific Course Objectives and Learning Outcomes:

By the end of the course, students will be able to:	… and be assessed through:
• **Perform basic engineering calculations:** ○ Convert quantities from one set of units to another quickly and accurately; ○ Define, calculate, and estimate properties of process materials including fluid density, flow rate, chemical composition variables (mass and mole fractions, concentrations), fluid pressure, and temperature.	Homework and exams
• **Perform material balance calculations:** ○ Draw and label process flowcharts from verbal process descriptions; ○ Carry out degree-of-freedom analyses; ○ Write and solve material balance equations for single-unit and multiple-unit processes, processes with recycle and bypass, and reactive processes.	Homework and exams
• **Perform applied physical chemistry calculations:** ○ Use basic equations of state to calculate molar flow rates based on data for volumetric flow rate, temperature, and pressure; ○ Calculate the partial pressure of a constituent of a gas mixture.	Homework and exams
• **Use basic computational tools:** ○ Use spreadsheets (EXCEL) to solve problems	Homework and project
• **Begin to understand the importance of safety issue** ○ Become aware and start evaluating potential safety hazards in processes, in particular, chemical processes	Specific homework
• **Work in problem-solving teams**	Project and in-class group activities

Course Requirements:
- Examinations: Three (3) exams, i.e., Exam 1, Exam 2 and Final Exam
- Homework: Assigned by the instructor as appropriate (typically weekly)
- Quizzes: Very short in-class quizzes on homework just completed (typically weekly)
- Project: A computer project will be assigned in the second half of the semester

Exams:
- There will be a total of three (3) exams, including the final exam
- A calendar of exams is included in the Course Outline given below
- All exams, with the exception of the final exam, will be one-class period long (~1 hr and 20 minutes) unless otherwise stated. The final exam will be 2 hr and 30 minutes long
- Only the following material can be used during the exams:
  - Textbook (printed version **only**)
  - Printed version of Prof. Armenante's *Course Notes* (posted on Canvas), possibly annotated during classes as students take notes on them
  - 1-page cheat sheet (both sides)
  - Conversion table sheet
  - Calculator

  - No homework, copies of homework solutions, past exams, and similar material will be allowed during the exams
  - ***During exams, students will <u>not be able to use computers or mobile phones</u> to communicate with anyone or access any sites***
    - For this reason, **you may want to purchase a hard copy of the textbook**
- Any change in the exam policy, if needed, will be announced by the instructor prior to the exams
- The final exam will be on <u>all</u> material covered throughout the course
- Make-up exams will only be given to students who cannot attend the regular exam time, *and only under documented and extraordinary circumstances*. In any case, no student will be allowed to take a make-up exam unless he/she has the <u>prior</u> consent of the instructor. *If a student will simply not come to an exam, the exam grade will automatically be zero*
- Because of confidentiality issues, the Office of the **<u>Dean of Students</u>** now handles all issues related to **medical conditions** (including justification for postponing exams)

<u>Quizzes</u>:
- Quizzes consist of short weekly in-class tests (last 10 minutes of a class period, typically on Wednesday)
- Quizzes are based on a the **most recent homework assignment** (e.g., one of the homework problems already assigned and collected, and for which <u>solution has been posted</u> already)
- Quizzes are **<u>close-book</u>, <u>close-note</u>**
- **Calculators** are allowed
- *During quizzes, students will **<u>not be able to use computers or mobile phones</u** to communicate with anyone or access any sites*

<u>Test and Homework Re-Grades:</u> If you believe that an error was made in grading the <u>homework or a quiz</u> you contact the TA with a short justification of your claim and attach it to the original homework/quiz in question. If you believe that an error was made in grading an exam or you would like to discuss any issues related to an <u>exam</u> you should contact Prof. Armenante instead. The "statute of limitation" for submitting such claims is one week after the homework/quiz/exam is returned.

<u>Homework Assignments</u>:
- Homework assignments will be posted on Canvas as appropriate (typically on a weekly basis)
- Students should turn in the homework by scanning it <u>as a **single** PDF file</u> with their phone (using Office Lens and/or CamScanner free apps) and uploading it to Canvas
- Students should **upload the completed assignments to Canvas** at the **beginning** of the class period when the assignment is due
- No late homework will be accepted unless a valid reason is provided **in advance** (e.g., an upcoming business trip)
- **Each problem** in each homework assignment will be graded by the TA using a scale from 0 (worst) to 10 (best). However, given the large number of students and problem only a simplified grading approach may be used (0, 5, 10)
  - Example: if a homework assignment contains 6 problems, the maximum number of points for that assignment will be 60/60
- Problem solutions will be posted on Canvas
- ***<u>Important Remark</u>**: Previous experience has clearly shown that those students who do not work on the assigned problems (or at least seriously try to solve them) typically perform very poorly on the exams.*

<u>Homework Format</u>:
- **Use** only **Engineering Format paper** or similar paper for the homework (a printable copy of the engineering Format paper is available in Canvas. Alternatively, you can buy a pad)
- **Use** appropriate **<u>graph paper</u>** (linear, log, semi-log) if necessary, or Engineering Format paper
- **Begin** each problem on a <u>new page</u>. However, short problems can be solved on the <u>same page</u>
- **Draw** a **<u>box</u>** around **all final numerical answers** to problems
- **Complete** all assignments in **<u>your own handwriting</u>**

- **Submit** problems in the **same order** as in the homework assignment
- **Include complete calculations** for all results presented to demonstrate how results were obtained
- **Include** all **units** for each term in each equation. The units must be **balanced**
- **Use** the appropriate number of **significant figures** (often two or three) for all results (but use at least two extra significant figures in calculations)
- **Use** Office Lens or CamScanner (free apps) on your mobile phone to **scan your homework** and create a **single pdf file**
- **Upload** your homework to Canvas by the due date
- Make sure that you **adhere to this format** to avoid losing points

Project:
- A computer project will be assigned in the second half of the semester
- The project can be completed by an individual student or by a team made of two students

Grading Policy: The grading policy for this course is as follows:
- Exam 1.....20%
- Exam 2.....20%
- Final exam 30%
- Quizzes 15%
- Homework.....10%
- Projects 5%

  Total 100%

***Important Remark**: **I do not grade on a curve** in this course*. It is theoretically possible for everyone in the class to receive an A (or an F). Your performance will depend **only** on **how you do**, not on how everyone else in the class does.

Course Final Grade: a tentative guideline for the assignment of final grades is the following:

Cumulative Points	*Overall Grade*
~90 to 100%	A
~75 to ~90%	B/B+
~60 to ~75%	C/C+
~50 to ~60%	"D"
0 to ~50%	F

Please remember that this is only a guideline designed to help the students understand how they are performing in the course. I will possibly slightly change the grading scale (both ways) when assigning the final grades.

I will assign the "D" grade only **sporadically**, since this implies that students in this grade category do not know appropriately well the critical content of course, which will be essential for the rest of their academic and work career. Instead students falling in the D-grade range will likely receive either a C or an F.

The grade of "Incomplete" will be given only under the most unusual and severe circumstances beyond control of the student.

If a student wishes to withdraw from the course, he/she may do so only before the date set by the Registrar's Office. Past this date a final grade will be assigned to the student.

Class Attendance: As required by NJIT policies "*All undergraduates are expected to attend all regularly scheduled classes*" (https://www.njit.edu/registrar/policies/attendancepolicy.php). In other terms, attendance is required. Irrespective of any policy consideration, students will not be able to pass the course unless they attend classes regularly to learn the important material covered in the lectures.

Laptop and Mobile Phone Use:

- Although technology opens up new learning possibilities for students, sometimes students utilize it in ways that are inappropriate. **Students cannot text, e-mail, surf the Internet, play games, use Facebook, instant messaging, etc., during class time** since this is a major distraction for the student doing it as well as for others, and prevents active class participation. Cell phones must be put on silent during class. However, students may use laptops to take notes during classes.
- ***During exams and quizzes, students will not be able to use computers and mobile phones to communicate with anyone or access any sites.*** For this reason, **students may want to purchase a hard copy of the textbook.**

Time Commitment: Because of its importance, students are expected to spend about six (6) hours/week in preparation for this course. Weaker students will find it necessary to spend more time.

Students are strongly urged to adjust their study and work schedule so that they will have time to cope with the demands for this course, as well as your other courses. **Falling behind in this course is extremely risky since it will be very difficult to catch up**.

This course is the **first true chemical engineering course** in the curriculum. It is likely that some students will find this course to be one of the most difficult courses taken in college. Through this course, students will be able to test their own interest in, and aptitude for, chemical engineering, while the instructor will evaluate each student's performance and potential for success in the field.

Code of Conduct and Academic Integrity: Academic Integrity is the cornerstone of higher education and is central to the ideals of this course and the university. Cheating is strictly prohibited and devalues the degree that students are working on. As members of the NJIT community, students have the responsibility to protect their educational investment by knowing and following the NJIT University Policy on Academic Integrity that is found at http://www5.njit.edu/policies/sites/policies/files/academic-integrity-code.pdf. The Code will be upheld on all issues related to the course. Students are expected to be familiar with the code and conduct themselves accordingly. Academic integrity is fundamental to the activities and principles of a university. All members of the academic community must be confident that each person's work has been responsibly and honorably acquired, developed, and presented. Any effort to gain an advantage not given to all students is dishonest whether or not the effort is successful. The academic community regards breaches of the academic integrity rules as extremely serious matters. Sanctions for such a violation may include academic sanctions from the instructor, including failing the course for any violation, to disciplinary sanctions ranging from probation to expulsion. When in doubt about plagiarism, paraphrasing, quoting, collaboration, or any other form of cheating, consult the course instructor. If students have additional questions about the code of Academic Integrity, they should contact the Dean of Students Office at dos@njit.edu.

Plagiarism and Academic Integrity: The approved "University Policy on Academic Integrity" is currently in effect for all courses. Should a student fail a course due to a violation of academic integrity, they will be assigned the grade of "XF" rather than the "F," and this designation will remain permanently on their transcript. All students are encouraged to look at the University Code of Academic Integrity and understand this document. Students are expected to uphold the integrity of this institution by reporting any violation of academic integrity to the Office of the Dean of Students. The identity of the student filing the report will be kept anonymous. NJIT will continue to educate top tier students that are academically sound and are self-disciplined to uphold expected standards of professional integrity. ***Academic dishonesty will not be tolerated.***

Students with Disabilities: NJIT adheres to Section 504 of the Rehabilitation Act (ADA) of 1990. Appropriate accommodations are provided at no cost to the student. Additional questions should be directed to the NJIT Office of Accessibility Resources and Services. For further information, students should visit https://www.njit.edu/studentsuccess/accessibility.

Important Dates According to NJIT Calendar (Fall 2021):

September	1	Wednesday	First Day of Classes
September	4	Saturday	Saturday Classes Begin
September	6	Monday	Labor Day
September	8	Wednesday	Monday Classes Meet
September	**8**	**Wednesday**	**Last Day to Add/Drop a Class**
September	8	Wednesday	Last Day for 100% Refund, Full or Partial Withdrawal
September	9	Thursday	W Grades Posted for Course Withdrawals
September	15	Wednesday	Last Day for 90% Refund, Full or Partial Withdrawal - No Refund for Partial Withdrawal after this date
September	29	Wednesday	Last Day for 50% Refund, Full Withdrawal
October	20	Wednesday	Last Day for 25% Refund, Full Withdrawal
November	**10**	**Wednesday**	**Last Day to Withdraw from Classes**
November	25	Thursday	Thanksgiving Recess Begins
November	28	Sunday	Thanksgiving Recess Ends
December	10	Friday	Last Day of Classes
December	11	Saturday	Saturday Classes Meet
December	12	Sunday	Sunday Classes Meet
December	13	Monday	Reading Day 1
December	14	Tuesday	Reading Day 2
December	15	Wednesday	Final Exams Begin
December	21	Tuesday	Final Exams End
December	23	Thursday	Final Grades Due

Additional important dates are available on the web at the following site:
http://www.njit.edu/registrar/calendars/.

Course Outline (Fall 2021)

Topic	Chapter in Textbook	Dates
Introduction to the Course		Sep. 1, 2021
Career Opportunities for Chemical Engineers	Chapter 1	
Principles of Chemical Process Calculations Systems of Units and Dimensions Conversion of Units Force and Weight	Chapters 2.1–2.4	Sep. 8-27, 2021
Dimensional Homogeneity and Data Analysis	Chapter 2.6	
Numerical Calculation and Estimation Computational Techniques	Chapters 2.5 and 2.7 Appendix A	
Processes and Process Variables	Chapters 3.1-3.6	
Exam 1		Sep. 29, 2021
Process Classification and Process Flow Sheets	Chapter 4.1	Oct. 4-Nov. 8, 2021
Fundamentals of Material Balances and Material Balance Calculations	Chapters 4.2, 4.3a-4.3d	
General Procedure for Material Balance Calculations	Chapters 4.3e and 4.3f	
Multiple Unit Processes	Chapter 4.4	
Exam 2		Nov. 10, 2021
Recycling and Bypass	Chapter 4.5	Nov. 15-Dec. 8, 2021
Reactive Processes	Chapters 4.6 and 4.7	
Combustion Reaction	Chapter 4.8	
Transient (Unsteady State) Processes	Chapters 10.1 and 10.2	
Final Exam (Cumulative)		Dec. 15-21, 2021

Important: It is conceivable that some changes in the above outline will take place, depending on the overall performance of the class and the time actually required to cover the most important subjects of the course.

Additional Resources

Following are materials that students may find useful and/or interesting.

- R.M. Felder, "An Engineering Student Survival Guide." Success strategies for engineering students (and all other students).
- L. Bullard, "A Survival Guide to Chemical Engineering." Suggestions to students beginning chemical engineering. Most of the suggestions are equally applicable to students in all other branches of engineering.
- R.M. Felder and J.E. Stice, "Tips on Test-Taking." Things students should and should not do when preparing for tests and taking them.
- R.M. Felder and R. Brent, "Why Students Fail Tests: 1. Ineffective Studying." *Chem. Engr. Education, 50*(2), 151-152 (Spring 2016). A cognitive science-based take on study strategies.
- R.M. Felder, "Memo to Students Who Are Disappointed with Their Last Test Grade." Suggestions for improving test grades.
- --, "Tips on Talks." Good practices in preparing and delivering formal oral presentations.
- --, "Impostors Everywhere." *Chem. Engr. Education, 22*(4), 168-169 (Fall 1988). The Impostor Phenomenon ("Everyone around me really belongs here but I really don't") as applied to engineering students.
- --, "Meet Your Students: 1. Stan and Nathan." *Chem. Engr. Education, 23*(2), 68-69 (Spring 1989). The sensor and the intuitor on the Myers-Briggs Type Indicator.
- --, "Meet Your Students: 2. Susan and Glenda." *Chem. Engr. Education, 24*(1), 7-8 (Winter 1990). The sequential learner and the global learner on the Felder/Silverman learning styles model.
- --, "Meet Your Students: 3. Michelle, Rob, and Art." *Chem. Engr. Education, 24*(3), 130-131 (Summer 1990). Three different approaches to learning (deep, surface, and strategic), and the conditions that induce students to take a deep approach.
- --, "Meet Your Students: 4. Jill and Perry." *Chem. Engr. Education, 25*(4), 196-197 (Fall 1991). The judger and the perceiver on the Myers-Briggs Type Indicator.
- --, "Meet Your Students: 5. Edward and Irving." *Chem. Engr. Education, 28*(1), 36-37 (Winter 1994). The extravert and the introvert on the Myers-Briggs Type Indicator, and to a good approximation, the active learner and reflective learner on the Index of Learning Styles.
- --, "Meet Your Students: 6. Tony and Frank." *Chem. Engr. Education, 29*(4), 244-245 (Fall 1995). The thinker and the feeler on the Myers-Briggs Type Indicator.
- --, "Meet Your Students: 7. Dave, Martha, and Roberto." *Chem. Engr. Education, 31*(2), 106-107 (Spring 1997). Three students at different levels of Perry's Model of Intellectual Development.

Students will also find useful material on

- The Math and Physics Help Home Page. This site contains instructive and entertaining pieces written by Gary and Kenny Felder with titles like "Think like a physicist," "What dx actually means," "Trigonometry Overview," and "Gödel's Theorem."