CHE 201 – Material and Energy Balances

Otto H. York Department of Chemical and Materials Engineering

New Jersey Institute of Technology

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Class Days/Times: Monday, 8:30-11:20AM, TIER-411B (Computer Lab)

Wednesday, 8:30-10:35, TIER-411B (Computer Lab)

Office Hours: TIER-321C M/W after class, til noon.

Teaching Assistant: [name and email]

Course Description: This course covers the basic principles of material and energy balances for a variety of chemical engineering systems. Basic unit operations and simple designs of chemical processes are introduced.

Prerequisites:CHEM 126 & MATH 112 or equivalent

Corequisites: CHE 101, CHE 230

Course Objectives: At the end of this course, students will be able to:

1. Perform material balance calculations: a.) Draw and label process flowcharts from verbal process descriptions; b.) Carry out degree-of-freedom analysis c.) Write and solve material balance equations for single-unit and multiple-unit processes, processes with recycle and bypass, and reactive processes
2. Write and solve material balance equations for single phase systems and multi-phase systems for steady-state processes with/out reactions
3. Write and solve energy balance equations based on the 1st law of thermodynamics for steady-state processes with/out phase changes or reactions
4. Derive and solve steady-state and transient material and energy balance equations for chemical processes

Learning Materials:

Reference Materials:

Required: Elementary Principles of Chemical Processes, 4th Ed., R. M. Felder, R. W. Rousseau & L. G. Bullard, Wiley, (2016). ISBN: 0470616296.

Digital resources: (Optional) - Material and Energy Balances by M. Libertore https://www.zybooks.com/catalog/material-and-energy-balances/

Hardware: A scientific or graphing calculator is required for solving complex engineering calculations

Software: MS Word and MS Excel 360, MATLAB (most recent version available at https://ist.njit.edu/matlab

Links to an external site.)

Grading: The final grade for the course is divided as follows:

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- Homework = 15%

- Quizzes = 15%
- Midterms (2 x 22.5%) = 45%
- Final Exam - cumulative - 25%

Grades will be assigned with the following rubric:

90% and above	A
85-89%	B+
80-84%	B
75-79%	C+
70-74%	C
60-69%	D
Below 60%	F

Please note, I always round up the final course grade to the next whole integer!

Assessments

Homework: Homework assignments will be posted weekly and must be submitted electronically on Canvas. No late homework will be accepted. While you are encouraged to work together to solve homework problems, each individual must submit their own work and will be graded

individually. No late work will be accepted, as solutions are posted immediately after the due date.

Quizzes: Quizzes will take place each week following the submission of the previous week's homework and will cover the material from that homework assignment. Quizzes cannot be made-up. However, if you miss a quiz and have a documented absence from the Dean of Students, that quiz's weight will be removed from your quiz average.

Active Learning Activities: In addition to 4 hours (2 hrs on two separate days) of lecture-based instruction each week, this course has a third one-hour active learning session, during which you will participate in a team-based or individual gamified and/or game based problem solving experience.

a.) These challenge problems will require the brainstorming of solution strategies and documentation of your work, which will also be assessed. Successful or partial completion of a challenge will result in the awarding of Experience Points (XP). XP will accumulate over the course of the semester, with the opportunity to "cash in" at strategic times for extra credit on graded assignments, using a conversion system.

Badges: Badges will be awarded to students who achieve scores of 100% on individual challenges, and other assignments throughout the semester. Some of these badges provide additional XP.

Exams: There will be two (2) 2-hour midterm exams and one (1) 2.5 hour final exam (cumulative). All exams are closed book and closed note. Complex and numerically intensive equations ex. equations of state, heat capacity formulas, Antoine's equation parameters etc… will be provided for you.

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 you are working on. As a member of the NJIT community, it is your responsibility to protect your

educational investment by knowing and following the academic code of integrity policy that is found at: http://www5.njit.edu/policies/sites/policies/files/academic-integrity-code.pdf

Links to an external site..

Please note that it is my professional obligation and responsibility to report any academic misconduct to the Dean of Students Office. Any student found in violation of the code by cheating, plagiarizing or using any online software inappropriately will result in disciplinary action. This may include a failing grade of F, and/or suspension or dismissal from the university. If you have any questions about the code of Academic Integrity, please contact the Dean of Students Office at dos@njit.edu.

Code will be provided to you for this course but under no circumstances should it be distributed outside of the course without the express written consent of the instructor.

Detailed Schedule:

Week	Topics	Assignment
1 9/4-9/9	Ch. 4.1-2 - Introduction to Balances • Classification of processes • The General Balance Equation • Differential and Integral Balances • Balances in everyday life	ALA 1: All the Balances, All the Time HW 1 Assigned
2 9/11-9/16	Ch. 4.3 -Steady-State Material Balances without Reaction • Degree of Freedom Analysis • Schematics from written descriptions • Scale-Up and Scale-Down • Unit Ops: Mixers and Separators	HW 1 Due Quiz 1 ALA 2: Mixer-Upper HW 2 Assigned
3 9/18-9/23	Ch. 4.4, 5 - Material Balances on Multi Unit Processes	HW 2 Due Quiz 2

	(No Reaction) • DOF Analysis on Multiple Units • Recycle, Bypass, Purge	ALA 3: Spin Cycle! HW 3 Assigned
4 9/25-9/30	Ch. 4.6 - Reactive Material Balances: Stoichiometry • Fractional Conversion, Yield, Selectivity, Extent of Reaction • Reaction Equilibrium	HW 3 Due Quiz 3 ALA 4: We-quilibrium HW 4 Assigned
Week 5 - Exam 1 - Ch. 4.1-5 10/3 - Exam Review, 10/7 Exam 1		
6 10/9-**10/21***	Ch. 4.7 - Reactive Material Balances • Degree of Freedom Analysis: Extent of Reaction Method Atomic Balance Method • Unit Ops: Batch & CSTR Single-Pass reactors • Multi-Pass Reactors and separation plants	HW 4 Due Quiz 4 ALA 5: (Linear) Independence Day HW 5 Assigned
***NOTE- I will be away at a conference 10/14-10/16 (No class)**		
7 10/23-10-28	Ch. 5 - Single Phase Systems • Density estimation • Virial Equation of state • Ternary Equations of State • Compressibility factor EOS	HW 5 Due Quiz 5 ALA 6: The Equation of State Challenge HW 6 Assigned
8 10/30-11/4	Ch. 7 - Introduction to Energy Balances • Steady state, Open and closed systems • DOF Analysis for Energy Balances	HW 7 Due Quiz 7 ALA 8: Pump it Up! HW 8 Assigned

Week 9 - Exam 2 - Ch. 4.6-7, Ch. 5, Ch. 7 Exam Review 11/6, Exam 2 11/11		
10 11/13-11/18	Ch. 8 - Energy Balances on Nonreactive Processes • Single Phase systems • Multiphase Systems, heat capacity and Enthalpy calculations • Unit Ops: Heat Exchangers, Compressors, Turbines	HW 8 Due Quiz 8 ALA 9: Inte-great! HW 9 Assigned
11 11/20-11/25	Ch. 9 - Reactive Energy Balances • Enthalpy of reaction, Heat of Formation, Combustion • Extent of Reaction Method • Atomic Balance Method • Unit Ops: CSTR Reactors with heat exchange	HW 9 Due Quiz 9 ALA 10: Things are Heating Up! HW 10 Assigned
Note: No class on Wednesday, 11/27 (Friday Schedule)		
12 12/2-12/4	Ch. 10 - Transient Material and Energy Balances • Derivation of transient balances • Simultaneous solution of material and energy balances • Unit Ops: liquid level, CSTR, Tank Heaters	HW 10 Due Quiz 10 HW 11 Assigned
13 12/9	ALA 11: Getting Computational	HW 11 Due
Week 14 - Final Exam Review - 12/11		
Final Exam - Cumulative		