Chemical Engineering 273
Chemical Process Principles (Material and Energy Balances)
MWF 9:00 am, 393 CB
Fall 2017

PROFESSOR Thomas H. Fletcher
350F CB, 422-6236 (tom_fletcher@byu.edu)

OFFICE HOURS I have not scheduled formal office hours. Please call, email, or come by to see me. My schedule is posted outside my door.

TEACHING ASSISTANTS Landon Nuttall (Landnut35@gmail.com), and
Hunter Lee (hunterjlee95@gmail.com). TA Hours to be announced.

PREREQUISITES Chem 106; or Chem 112; Ch En 170 or equivalent; Ch En 263 or concurrent enrollment; Math 113 or concurrent enrollment.

REQUIRED TEXT

R.M. Felder, R.W. Rousseau, and Lisa G. Bullard, *Elementary Principles of Chemical Processes, 4th Edition 2016*, John Wiley and Sons, NY, 2005 (ISBN-13 978-0-470-616291-). This comes as a 3-ring binder version, but can be spiral bound in the bookstore.

CLASS WEBSITE http://www.et.byu.edu/~tom/classes/273/273.html
(assignments, homework hints, and current grades will be posted here)

ADDITIONAL SOURCES

R.L. Rowley, ChEn 273 Learning Resource Center http://www.et.byu.edu/~rowley/ChEn273/index.html
Dr. Hedengren made videos of many lectures. See the class webpage.

COURSE OBJECTIVES

A. Obtain a feel for what Chemical Engineers do
B. Learn about basic chemical process units
C. Learn to analyze and solve material balance problems
D. Learn to analyze and solve energy balance problems
E. Learn to analyze more complex balance problems involving coupling of material and energy balances for multiple units

GRADES

Grades will be determined from (i) a passing grade on the final exam, and (ii) a composite score of all graded materials. A passing grade on the final exam will be 60%. This is a reasonable score to prove that you have learned most of the material. Anyone earning between 50% and 60% on the final exam will have 10% of the grade percentage deducted. A score of lower than 50% on the final exam will result in 20% of the grade percentage deducted. The composite score will consist of: three exams, homework problems, a case study project and the comprehensive final exam. The three exams will be weighted at 10%, 15%, and 20%, respectively. Weights used to determine the final score will be:

1. Homework problems, Quizzes, In-Class Activities	20%
2. Case study	10%
3. Three midterm exams	45%
4. Final Exam	25%

DEAN'S LECTURES

All ChEn 273 students are required to attend **two** Dean's Lectures or equivalent during Fall semester. Alternate seminars are graduate student seminars, SWE speakers, or other approved outside speakers. Notify the TAs when you have attended each lecture. The tentative dates for the Dean's Lectures are **Oct. 5** and **Nov. 9. This will be worth ½ grade (A- vs. A).** Please mark your calendars.

BYU HONOR CODE

In keeping with the principles of the BYU Honor Code, students are expected to be honest in all of their academic work. Academic honesty means, most fundamentally, that any work you present as your own must in fact be your own work

and not that of another. Violations of this principle may result in a failing grade in the course and additional disciplinary action by the university. Students are also expected to adhere to the Dress and Grooming Standards. Adherence demonstrates respect for yourself and others and ensures an effective learning and working environment. This includes the requirement that shorts and skirts be knee length or longer, tops are not low cut, and that men shave. Please do not embarrass the instructors, TA's, or yourself by dressing inappropriately; your integrity is on display. It is the university's expectation, and every instructor's expectation in class, that each student will abide by all Honor Code standards. Please call the Honor Code Office at 422-2847 if you have questions about those standards.

Each student is expected to submit for credit only that work of which he/she is the sole author (except for the case study). Students are encouraged to work in groups to discuss problems and possible solution ideas, but each student's work must represent his/her own thinking, labor, and understanding. The following are examples (but by no means an exhaustive list) of Honor Code violations:

- Copying another student's work or an unauthorized answer key and submitting that copied material for credit as one's own work
- **Using any materials, either homework problems or exams, from previous years**
- Relying on the thinking and efforts of another person as a major guide in doing one's own homework without substantial effort to contribute one's own thought, labor, or understanding
- Sharing electronic copies of homework (Mathcad files, Excel spreadsheets); please turn in separate sheets with original work
- Obtaining unauthorized information during an examination, such as from the examination paper of another student or from unauthorized written material
- Using false information to obtain undeserved permission or credit or to avoid a deserved penalty.

UNIVERSITY MISSION

The following is quoted from the General Catalog. "The mission of Brigham Young University - founded, supported, and guided by The Church of Jesus Christ of Latter-day Saints - is to assist individuals in their quest for perfection and eternal life. That assistance should provide a period of intensive learning in a stimulating setting where a commitment to excellence is expected and the full realization of human potential is pursued. To succeed in this mission the university must provide an environment enlightened by living prophets and sustained by those moral virtues which characterize the life and teachings of the Son of God."

PREVENTING SEXUAL MISCONDUCT

As required by Title IX of the Education Amendments of 1972, the university prohibits sex discrimination against any participant in its education programs or activities. Title IX also prohibits sexual harassment-including sexual violence-committed by or against students, university employees, and visitors to campus. As outlined in university policy, sexual harassment, dating violence, domestic violence, sexual assault, and stalking are considered forms of "Sexual Misconduct" prohibited by the university.

University policy requires any university employee in a teaching, managerial, or supervisory role to report incidents of sexual misconduct that come to their attention through various forms including face-to-face conversation, a written class assignment or paper, class discussion, email, text, or social media post. If you encounter Sexual Misconduct, please contact the Title IX Coordinator at t9coordinator@byu.edu or 801-422-2130 or Ethics Point at https://titleix.byu.edu/report or 1-888-238-1062 (24-hours). Additional information about Title IX and resources available to you can be found at http://titleix.byu.edu.

STUDENTS WITH DISABILITIES

BYU is committed to providing a working and learning atmosphere that Brigham Young University is committed to providing a working and learning atmosphere that reasonably accommodates qualified persons with disabilities. If you have any disability which may impair your ability to complete this course successfully, please contact the University Accessibility Center (UAC), 2170 WSC or 422-2767. Reasonable academic accommodations are reviewed for all students who have qualified, documented disabilities. The UAC can also assess students for learning, attention, and emotional concerns. Services are coordinated with the student and instructor by the UAC. If you need assistance or if you feel you have been unlawfully discriminated against on the basis of disability, you may seek resolution through established grievance policy and procedures by contacting the Equal Employment Office at 422-5895, D-285 ASB.

AIChE CODE OF ETHICS[1]

A. Fundamental Principles

Engineers shall uphold and advance the integrity, honor and dignity of the engineering profession by:

1. Using their knowledge and skill for the enhancement of human welfare;
2. Being honest and impartial and serving the engineering profession with fidelity;
3. Striving to increase the competence and prestige of the engineering profession.

B. Fundamental Canons

1. Engineers shall hold paramount the safety, health, and welfare of the public in the performance of their professional duties.
2. Engineers shall perform services only in areas of their competence.
3. Engineers shall issue public statements only in an objective and truthful manner.
4. Engineers shall act in professional matters for each employer or client as faithful agents or trustees, and shall avoid conflicts of interest.
5. Engineers shall build their professional reputations on the merits of their own service.
6. Engineers shall act in such a manner as to uphold and enhance the honor, integrity, and dignity of the engineering profession.
7. Engineers shall continue their professional development throughout their careers and shall provide opportunities for the professional development of those engineers under their supervision.

[1] Adopted by Council, August 16, 1980; based on ECPD Code of Honor, October 5, 1977.

I. CLASS MECHANICS

A. Homework Problems

Homework is an essential, integral part of this course because problem solving skills are obtained only by solving problems (lots of problems!). This is your major! Do all the homework! Do not assume that you have learned the material just because you can follow the instructor's solutions. Starting from scratch on a problem is a higher level of understanding than simply understanding how someone else worked the problem.

Homework rules:

1. Homework problems are due at the beginning of class. Please don't be late to class because you are finishing homework.
2. Homework may be turned in until the next exam without excuse for up to 50% credit. You may look at the answer key on Learning Suite for guidance on late homework. Dr. Fletcher will excuse late homework on a case-by-case basis. Please work the homework early to avoid lateness due to computer crashes.
3. Answer keys will be posted on the Learning Suite after class.
4. You may discuss with others how to begin working problems (in fact this is encouraged), but you must work the problem entirely yourself to hand in for credit. You may **not** share computer files for homework problems until the case study.
5. Homework should be written on one side only of 8.5" x 11" paper. Neatness is essential in developing good problem solving techniques. Points may be taken off for sloppiness.
6. Use of Mathcad will not be permitted on some assignments and encouraged on others. This will be made clear on the class schedule.

B. Standard Homework Format

1. Organize work carefully and logically. Write legibly and neatly.
2. Carry units all the way through to the final answer. Units should appear on all numbers.
3. Carry algebraic expressions analytically as far as possible before substituting numbers.
4. Underline, box or otherwise mark results and answers.
5. Label your first page with a heading containing ChE 273, your name, assignment number, date and page. Subsequent pages should contain at least the page number and your name or initials.
6. Write on only one side of the paper (engineering paper is preferred).
7. Before turning in your assignment, staple all sheets together in upper left-hand corner. The TAs have requested that you do not fold the assignments. I will not provide a stapler.

C. Computer Problems

The computer is a valuable tool in this class and you should use spreadsheets, graphics packages, and programming languages. You should become conversant in MATHCAD and EXCEL, since they will be great tools for you in this class and throughout the chemical engineering curriculum. It is expected that you already know how to use MATHCAD and EXCEL because you should have taken ChEn 263. If you are a transfer student and are not familiar with MATHCAD, the teaching assistants will be glad to help you get started. Several problems assigned will require use of MATHCAD. You are free to use EXCEL on any of the other problems as you see fit; some restrictions apply on MATHCAD.

D. Exams

Exams will be closed book to see if you know the material. I am planning to have timed, take-home exams. I trust you to be honest, but will move to 1-hr in-class exams if my trust is broken.

E. Final Exam

The final exam for the course will be given on **Monday, December 18 at 7:00 to 10:00 am in the regular classroom**. It will be a comprehensive, open-book final. **Finals will not be given at any other time**.

F. Reading Assignments

You are expected to keep up with the reading assignments on your own initiative. Assignments for each day of the entire course are listed on the attached schedule. You should read the assigned material before class. We will not remind you in class to do the reading. That does not mean it is not important. Generally, poor performance on exams is a result of not doing the reading. Quizzes will be given occasionally on the reading material at the beginning of class.

G. Case Study

Midway through the course the class will be divided into groups of 4-5 students. Your group will be assigned a case study to work on as a group. The case study involves balances on a process involving multiple chemical process units and is a good capstone problem for the course. Your group will interact with a consultant, either with me or with one of the TA's. I will introduce the case study and talk about the process in general, but then your groups will need to be self-motivated to meet regularly to discuss the problems and prepare a design for the project.

On the last day of class, you are to turn in the following items for grading of the case study:

(a) A completed case study report from your group showing the overall design of the process with appropriate stream tables, etc., and answers to questions. This should be done neatly and professionally. Only one report should be turned in for each group.

(b) Each individual should turn in a single page table that provides his/her confidential evaluation of the contribution of each group member.

An overall score will be assigned to each group's case study. Additional points will be added or subtracted depending on any clear evidence from the contribution evaluations that particular individuals made extraordinary or sub-standard contributions. Thus, individual scores may vary slightly within any one group.

H. TA Help Session

During the first week of class, we will schedule hours that the TA's will be available. You are encouraged to come by during those hours and seek help on problem assignments.

II. PROBLEM SOLVING PROCEDURES

Have you ever been trying to solve a problem (not necessarily a chemical engineering problem) and become totally lost in the middle of it, not really knowing where you've been or possibly not even remembering what it was that you were trying to solve for in the first place. CHE 273 is a problem solving course and learning to attack a problem in an organized fashion is an important step in an engineer's education. To avoid the onset of panic caused when you get lost in the middle of a problem and to provide you with a generalized decision making scheme, I have outlined below the typical sort of procedures that I might use in attacking a problem. While I don't require you to memorize this procedure, I do expect that you will consistently set your problems up in the general fashion described below. You should begin to use this approach immediately in this class. As this approach becomes second nature to you, your problem solving capabilities will be greatly enlarged and (importantly) you will be able to attack material and energy balance problems with a great deal of self confidence.

General Problem Solving Approach

A. DEFINE

1. Draw a sketch of the problem.
2. Label the sketch with flows and composition for each steam.
3. Put all known values of compositions and flows on the sketch.
4. Select a basis of calculation.
5. List the unknown stream quantities with symbols.
6. Identify exactly what you are being asked to calculate.

B. EXPLORE

1. Select the system boundaries.
2. Determine the degrees of freedom and the number of equations to be solved.
3. Obtain the necessary data and physical properties.
4. Identify possible attacks.
    i. Use equations with fewest unknowns first.
    ii. Use tie-components if appropriate.
    iii. The overall balance should generally be used.
    iv. Relocate the basis if necessary.
    v. For multiple units, start with the unit which has the lowest degree of freedom.
5. Write down independent balance equations for the chosen attack.

C. SOLVE

1. Solve simultaneous equations.
2. Scale-up from the chosen basis.

D. CHECK

1. Check your answers by direct substitution.

III. Competencies.

This course will help students should accomplish the competency expectations listed on the next page.

Level 3 competencies: Fundamental concepts that all chemical engineers should know. The Level 3 Competency exam must be taken and passed during the senior year of chemical engineering as a graduation requirement. This exam includes a total of twenty-four Level 3 competencies, including the Level 3 competencies from this class.

Level 2 competencies: Important concepts that will be taught. Measurements of student learning will include homework and exam questions. These often include more complex material.

Level 1 competencies: Students are exposed to the material, but there is no minimum performance expectation.

You will be asked at the end of the course to evaluate how competent you feel with the expectations listed on the next page.

Level	Usage	Competency Expectation
3	P	Students will demonstrate an ability to solve engineering problems.
3	M	Students will be able to use basic engineering units in both SI and AES systems in solving problems, and be able to convert between unit systems both by hand and with an equation solver.
3	M	Students will be able to solve steady-state, overall, material and energy balances for systems which include one or more of the following: recycle, multiple units, chemical reactions.
3	M	Students will understand the phase behavior of pure substances in relationship to the variables T, P, and density (including vapor pressure, critical point, freezing line, triple point, etc.).
3	M	Students will be able to use the mechanical energy balance equation to solve fluid flow problems both with and without friction.
3	M	Students will be introduced to the first law of thermodynamics for closed and open systems.
3	M	Students will understand and be able to use the extent of reaction in material balances
2	R	Students will be able to solve numerical and symbolic problems using advanced math software (e.g. Mathcad).
2	P	Students will exhibit critical and creative thinking skills for analysis and evaluation of problems and cause-effect relationship.
2	P	Students will be able to obtain and evaluate appropriate input information/data from databases, handbooks, correlations, experiments, literature, etc.
2	P	Students will be introduced to the notions of rationalizing units, making order of magnitude estimates, assessing reasonableness of solutions, and selecting appropriate levels of solution sophistication.
2	P	Students will be introduced to how safety considerations are incorporated into engineering problem solving.
2	P	Students will be introduced to how environmental considerations are incorporated into engineering problem solving.
2	P	Students will practice good teamwork principles.
2	M	Students will learn about chemical processes, units, and corresponding equipment.
2	M	Students will be able to set up and solve simple transient material balances.
2	M	Students will be able to use a degree-of-freedom approach to assist in the solution of material and energy balances.
2	M	Students will be able to read mixture phase diagrams (solid solubility, liquid-liquid, VLE) and construct mass balances from them using the lever rule, tie lines, etc.
2	M	Students will be able to solve simple fluid statics problems (e.g., manometers, fluid head, etc.).
2	M	Students will be able to apply Raoult's law to solve VLE problems including bubble point, dew point, and flash calculations.
2	M	Students will be introduced to equations of state and corresponding states correlations.
2	M	Students will be introduced to the concepts of heat capacity, latent heat, heat of reaction, heat of combustion, and heat of formation.
2	M	Students will be introduced to process variables (e.g., P, T, flow rate, conc.) and their measurement.
2	M	Students will be able to use a problem solving strategy to define and solve engineering problems.
2	M	Students will demonstrate experience working together in teams.
2	I	Students will be introduced to calculations involving work in turbines, compressors, and pumps.
2	I	Students will be introduced to the AIChE code of ethics.

I=Introductory, M=Main place where material is presented, P=Programmatic material, R=Review