ChE 201 – Material and Energy Balances

Lecture: 9:30 a.m.—10:20 a.m. MWF, JH 283
Lab: 1:10 p.m.—2:25 p.m. TTh, JH 207

Catalog Description:
ChE 201: Material and Energy Balances Credit 4.
Chemical Engineering basic problem-solving skills; unit conversions; elementary stoichiometry; material balances; energy balances; combined energy and material balances including those with chemical reaction; purge and recycle; thermochemistry; application to unit operations; sources of data; introduction to the first law of thermodynamics and its applications. Chemical engineer majors must earn C or better in the course.

Prerequisites:
Ch E 111, Math 192, and Chem 111 or 115. Ch E 201H same as Ch E 201 but additional work to be arranged.

Textbook:
- Felder and Rousseau, *Elementary Principles of Chemical Processes*, 2005 Edition with Integrated Media and Study Tools, John Wiley and Sons, New York, 2005.

References:
- Perry & Green, *Perry's Chemical Engineering Handbook*, 7th edition, McGraw-Hill Book Company, New York, 1997.
- R. C. Reid, J. M. Prausnitz and B. E. Poling, *The Properties of Gases & Liquids*, 5th edition, McGraw-Hill, New York, 2000.

Course Objectives:
At the end of this course the student will be able to (the mapping of these objectives to ABET outcomes a-k):
- Determine individual learning style and describe how learners of that style can help themselves (outcome (i) a recognition of the need for, and an ability to engage in life-long learning),
- Use Excel and MathCAD to solve material and energy balance problems (outcome (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice),
- Work in a group to propose a solution to an open-ended environmental problem (outcome (d) an ability to function on multi-disciplinary teams, outcome (c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability),
- Write a report summarizing the proposed solution for an open-ended problem (outcome (g) an ability to communicate effectively),
- Correctly implement unit conversions (outcome (a) an ability to apply knowledge of mathematics, science, and engineering),

- Analyze and solve elementary material balances on single and multi-unit process, for both nonreactive and reactive processes (outcome (a)),
- Apply the first law of thermodynamics to batch and flow processes (outcome (a))
- Locate thermophysical property data in the literature and estimate properties when data are not available (outcome (a) and outcome (k)),
- Conduct combined material and energy balances around continuous multi-unit processes with and without chemical reaction (outcome (a)),
- Perform process calculations using psychrometric charts, enthalpy concentration diagrams and steam tables (outcomes (a) and (k)),
- Derive and solve differential equations for transient heat and material balances on dynamic systems (outcome (a)).

Topics Covered:
1. Introduction to engineering calculations—Chpt. 2
2. Process variables—Chpt. 3
3. Material balances—Chpts. 4-6 Felder and Rousseau
4. Energy and energy balances—Chpt. 7 Felder and Rousseau
5. Material and energy balances on nonreactive processes—Chpt. 8 Felder and Rousseau
6. Material and energy balances on reactive processes—Chpt. 9 Felder and Rousseau
7. Transient balances—Chpt. 11 Felder and Rousseau

Final Exam: 8:00—10:00 a.m. Monday, December 8, 2008.

Contribution of course to meeting the professional component:
This course addresses the following professional components as prescribed by ABET for Chemical Engineering and similarly named programs:
- A working knowledge of material and energy balances applied to chemical processes
- An introduction to thermodynamics of physical and chemical equilibria
- An introduction to chemical reaction engineering and process design

Relationship of course to departmental objectives:
This is the second chemical engineering course taken by NMSU chemical engineering majors. It addresses the Department's mission and objectives by developing the student's foundation to successfully practice chemical engineering by building on skills in solving chemical engineering science, design and practice. Teamwork and communication skills are also developed as is the student's recognition of ethical behavior in the profession.

Differentiated Assignments for Honors Students:
Students registered for 201H will be required to prepare a report. This report usually describes the process flowsheet and the heat and material balance for a classical chemical engineering processing plant such as an oil refinery, a sulfuric acid plant, an ammonia plant, an air separation plant, etc. Other report topics may be proposed by the student to the instructor. An oral presentation to the class of approximately 10 minutes in length summarizing the main points of this report will also be required.

Written and Oral Communication:
Students will be assigned to groups to complete a month long project that will result in a written report. Honors students (registered for Ch E 201H) will prepare a written report and make an oral presentation (which may be videotaped) to the class describing an important chemical process, including its heat and material balance, its safe design and operation, its potential for environmental impact, and its economics. This process will be selected with the advice and consent of the instructor.

Guidelines for Homework:
1. Refer to R. L. Long, B. Barna, C. W. Bridges, A. L. Rakow, and D. B. Wilson, *Guide to Writing and Problem Solving for Chemical Engineers*, pp. 24—27 (available in the Shires Reading Room).
2. Summary of guidelines (not including individual problem parts described by Long et al.)
    a. All solutions will be submitted on 8 ½" x 11" paper.
    b. Solutions will be presented on one side of each sheet only.
    c. Each page of an assignment will contain the following in the upper right margin:
        Student's name
        Course number
        Date due; x/y
        (x/y indicates the xth page of a total of y pages in the assignment).
    d. The conclusion of your solution (your answer) must be boxed.
    e. The pages of your solution should be arranged in numerical order, stapled in the upper left corner and folded lengthwise down the center. Your name, the course number and the date should be shown on the right half of the reverse side of the last sheet.
3. Clarity and neatness are vital. If you do not show your work you will not receive full credit.

Grading:
Three 75-minute examinations will be given during Thursday meeting times. All examinations will be closed book unless otherwise announced. Each examination will count 100 points and may cover any material (lecture, homework, laboratory or assigned reading) since the previous examination. **A comprehensive make-up examination will be offered on Friday, December 5, 2008 at 2:30 p.m. for an unavoidable absence from one examination**.
The final examination will be two hours in length and cover the complete course. The final examination will be worth 250 points. **No make-up final examination will be given**.

Homework will be coordinated with lectures and will also be assigned and due approximately one week after assignment. Additional homework drawn from reference material may be assigned. Late homework may be submitted for grading, but will be assigned the following penalties: 1 day late: 50% credit, 2 days late: 25% credit, 3 days late: 10% credit. Homework can be turned in early if a student expects to be absent. The total of all homework will be 150 points.

The project, worth 100 points, will be a team project, assigned in November and due at the end of the semester. The project will involve proposing a solution to an engineering problem, and presenting material and energy balances as part of this proposed solution. Each group will submit a written report of its solution.

A class participation grade will be assigned based on completion of in-class assignments, questions asked and preparedness, including bringing the text, the syllabus, and any supplementary material to **each** class session. The participation total will be 100 points.

The TTh portion of the course (known as "recitation" at some universities) will be focused on problem-solving and class participation. Attendance at recitation will be taken periodically. In addition, in-class assignments will be completed, and will be turned in for credit towards the recitation grade. Attendance at recitation will be very useful, as problems (both assigned homework and supplementary) will be solved. Recitation is also an ideal forum for asking questions of classmates and of the instructor. A recitation score, based on participation, attendance and completion of in-class assignments, will be 100 points.

The total point accumulation and final grade distribution for this course will be as follows:

Examinations	300 Points	900—1000 Points	(90—100%)	A
Final	250 Points	800—899.99 Points	(80—89%)	B
Homework	150 Points	700—799.99 Points	(70—79%)	C
Recitation	100 Points	600—699.99 Points	(60—69%)	D
Class participation	100 Points	<600.00 Points	(< 60%)	F
Project	100 points			
Total	1000 Points			

The goal for everyone in this class should be to make a grade of B or better. Since this course is a prerequisite to all further chemical engineering courses, a grade of at least C is required to proceed in the curriculum. Hence, a D is no better than an F.

Attendance Policies:
Attendance at all classes is strongly recommended. Attendance is **required** for all examinations. If a student arrives late for any examination, the student must complete the examination at the same scheduled time as all other students. **A single, closed-book, closed-note, comprehensive make-up examination, covering all the material in the course, will be offered Friday, December 5, 2008 from 2:30 p.m.—3:30 p.m**. If a student must miss one scheduled examination, the score from this comprehensive examination can be substituted for the missed examination. If a student wishes to take the comprehensive make-up exam, the student must notify Dr. Mitchell by December 1, 2008.

Withdrawals:
Students **will not** receive an automatic drop for persistent absences or persistent failure to complete assignments. The responsibility for withdrawals is completely up to the student.

Academic Misconduct:
Teamwork on homework and laboratory projects is encouraged for learning purposes. However, all assignments turned in by the student must show the **student's own work**. Any evidence that a student has access to and/or is copying homework answers from the *Instructor's Manual* for the text for this course will result in that student receiving zero for **all** homework for this course. All examination answers must be **strictly one's own work**. Department policy is that any student suspected of cheating or aiding other students to cheat will receive a zero for that assignment and a sealed letter (with a confidential copy to the student) detailing the incident marked "Destroy on Graduation" will be placed in the Department Head's sealed files. A second incident of suspected cheating is deemed sufficient cause for expulsion of that student from the Department. The student is referred to the Student Code of Conduct in the *NMSU Student Handbook* for policy and procedures that will be strictly followed in the event of any academic misconduct.

Incomplete Grades:
A grade of Incomplete (I) is given **only if the student is passing** and can not complete the required work for reasons beyond the student's control. The student is referred to the current *NMSU Undergraduate Catalog* for the regulations that apply to removing or changing an I grade.

Extra Credit:
There will be several opportunities over the course of the semester to earn extra credit points (by attending the ice cream social, AIChE meetings, etc.). These opportunities will be announced in class. The extra credit will be considered when assigning final grades.

ADA:
If you have (or believe you have) a disability and would benefit from classroom accommodation(s), please contact the Services for Students with Disabilities (SSD) Office located at Corbett Center, Room 244 [Phone: 646-6840: TTY: 646-1918]

Student Responsibilities:

1. Register with SSD and obtain accommodation documents early in the semester;
2. Deliver the completed accommodation and testing form(s) to the instructor(s) within the first two weeks of beginning of classes (or within one week of the date services are to commence);
3. Retrieve the signed form(s) from faculty and return to SSD within (5) days of the receipt from faculty and at least one week before any scheduled exam; and,
4. Contact the SSD Office if the services/accommodations requested are not being provided, not meeting your needs, or if additional accommodations are needed. Do not wait until you receive a failing grade. Retroactive accommodations cannot be considered.

Faculty Responsibilities

1. Sign the *ACCOMMODATION REQUEST FORM* and *TESTING ACCOMMODATION FORM* (when presented), retain a copy, and return the original to the student within five (5) working days of receipt;

2. Contact SSD immediately if there are any questions or disputes regarding accommodation(s), disruptive behavior, etc.; and,

3. Refer the student to SSD for any additional accommodations.

Feel free to call Jerry Nevarez, Director of Institutional Equity, at 505-646-3635 with any questions you may have about NMSU's Non-Discrimination Policy and complaints of discrimination, including sexual harassment.

If you have a condition which may affect your ability to exit from the premises in an emergency or which may cause an emergency during class, you are encouraged to discuss this in confidence with the instructor and/or the director of Disabled Student Programs.

Feel free to call Michael Armendariz, Coordinator of Services for Students with Disabilities, at 505-646-6840 with any questions you may have on student issues related to the Americans with Disabilities Act (ADA) and/or Section 504 of the Rehabilitation Act of 1973. All medical information will be treated confidentially.

Coordinator:
Dr. Martha C. Mitchell, Professor of Chemical Engineering
Office: 259 Jett Hall 646-2093 martmitc@nmsu.edu
Office Hours: MTWF 10:30 a.m.—11:20 a.m., TTh 2:30 p.m.—3:00 p.m, *or by appointment.*
Date prepared: August 19, 2008

Biographical Sketch
Martha C. Mitchell

Dr. Mitchell is a Professor and the Academic Department Head of Chemical Engineering at New Mexico State University. She joined the NMSU faculty in August 1996 after completing her Ph.D. at the University of Minnesota-Minneapolis. Her dissertation was titled "Predicting Adsorption of Fluids Confined to Nanoporous Media." She received her B.S. ChE from the University of Wisconsin-Madison. In the summer of 1997 she worked at Exxon Research & Engineering in Annandale, New Jersey modeling fluid catalytic cracking (FCC) units. In the summer of 2001 she worked at Sandia National Laboratories in Albuquerque, New Mexico modeling transport in ion channels using Molecular Density Functional Theory and the massively parallel computers available at Sandia. She became registered as a Professional Engineer in the State of New Mexico in 2002.

Dr. Mitchell first gained teaching experience at the University of Minnesota, where she was the instructor for a sophomore-level course, ChEn 3001, Programming for Computational Methods. Since joining the faculty at NMSU she has taught many undergraduate courses, ChE 101, ChE 111, ChE 201, Chemical Process Calculations, ChE 301, Chemical Engineering Thermodynamics, ChE 315L, Process Instrumentation Laboratory, ChE 361, Engineering Materials and ChE 412, Chemical Process Control. She has also taught several graduate-level courses, including Ch E 501, Intermediate Thermodynamics and Transport Processes, ChE 514, Intermediate Chemical Engineering Calculations, ChE 590/690 Graduate Seminar and ChE 602, Statistical Thermodynamics. She is one of the advisors for the NMSU section of the Society for Women Engineers.

Molecular modeling of industrially-relevant processes is the focus of Dr. Mitchell's research program. Zeolites are porous aluminosilicates with pore sizes on the order of 2-14Å. Currently she is interested in modeling the separation of light gases in zeolite films, which is of great interest to the natural gas industry, and of modeling the immobilization of radioactive species in zeolite matrices. Her collaborator at Sandia National Laboratories, Tina Nenoff, is a materials chemist who fabricates thin films of zeolites and other molecular sieves. Dr. Mitchell currently advises one Ph.D candidate: Krishna Upadhyayula, who is using molecular dynamics simulations and Monte Carlo simulations to model adsorption of water and ions in carbon nanotubes. Two M.S. students, Stan Indurthi and Mahesh Naalla, have starting working on modeling hydrogen adsorption in metal-organic frameworks. Cessna Baca, a ChE undergrad, is working with Dr. Mitchell, under an Alliance for Minority Participation fellowship, to accurately predict vapor-liquid equilibrium for hydrazine as well as mixtures of hydrazine and water. This thermodynamic characterization will be used to improve safety and design calculations for these fuels. All of these efforts require the implementation of thermodynamics, mechanics and statistical mechanics in computational code.

Dr. Mitchell's hometown is Columbia, MO. She and her husband, Dr. Shaun Cooper, are kept very busy with their six and a half year old son, John, their two and a half year old son, David, and their two dogs, Wiggles and Lucy.