Syllabi are presented in the following order:
CEE courses
ENGR courses
CHE courses
ENVE courses

Department, number and title of course: Department of Chemical and Environmental Engineering, CEE 10/11 – Introduction to Chemical and Environmental Engineering/ Introduction to Bioengineering

Required/Elective course: Required Course

Catalog description: Introduction to chemical and environmental engineering for engineering majors and nonengineering majors. Aims to enrich students' appreciation of chemical, biochemical and environmental engineering. Discusses the application of concepts and methods of the physical sciences and mathematics to problems in the life sciences. Graded Satisfactory (S) or No Credit (NC).

Prerequisite(s): None

Textbook(s) and/or other required material:
Shreve's Chemical Process Industries by Shreve, , 5th edition, McGraw-Hill, New York, 1984.
Introduction to Bioengineering by Berger, Goldsmith, and E.R. Lewis (eds.), Oxford University Press Inc., New York, 1996.

Course objectives:
1. Familiarity with numerous chemical, biochemical and environmental engineering processes and typical careers
2. Ability to research and compile a technical review on a chemical or environmental process including process block diagrams
3. Plant tours to environmental and chemical industries to familiarize students with day to day operations, safety considerations, and troubleshooting requirements.
4. Familiarity to research and internship opportunities
5. Ability to present research topics to a large audience within time allotted
6. Familiarity with library system for research topics and computer lab usage
7. Ability to use computer software for word processing, constructing tables and graphs, data analysis and making presentation slides.
8. Knowledge of latest developments in the field.

Topics covered: Potential careers in chemical, environmental, and bioengineering, code of ethics, topics related to the pharmaceuticals, power generation, and wastewater treatment industries, green engineering and sustainability, genetic engineering, and biomaterials. Other topics include presentation skills, researching with library aids and efficient use of softwares including Word, Excel, Powerpoint, and MATLAB, and research opportunities.

Class/laboratory schedule: Discussion, 1 Hour; laboratory, 3 hours.

Assessment methods:
(*Satisfactory / No Credit)* will be based on the fulfillment of the following:
- Attendance of <u>all</u> lectures, labs, field trips, guest speaker sessions
- Lab Tutorials and Software exam (must obtain passing grade on each lab and exam section)
- Team Oral Presentation (10 min)

Contribution of course to meeting the professional component:
This course serves as an introduction to the chemical, environmental and bioengineering professions. The code of ethics is introduced to provide the students with an awareness of the professional and ethical responsibilities of engineers. Skills required for success in the field including team building,

effective communication, ability to research, organize and relay information from technical topics, application of computer softwares for efficient report writing, data analysis, and organization of presentation materials, are emphasized. Field trips to industrial sites provide a real world component to the course. The importance of internship and research opportunities are addressed as well as highlighting the relationship between the core courses and their application to the profession.

Relationship of course to program outcomes: The contribution of CEE 10/11 to program outcomes (a)-(k) or (1) – (11) is summarized in the objective-outcome matrix table

Objective-Outcome Matrix
Objective Addresses Outcome: 1-Slightly 2-Moderately 3-Substantially

Outcome Related Learning Objectives	**Outcome 1**	**Outcome 2**	**Outcome 3**	**Outcome 4**	**Outcome 5**	**Outcome 6**	**Outcome 7**	**Outcome 8**	**Outcome 9**	**Outcome 10**	**Outcome 11**
Familiarity with numerous chemical, biochemical and environmental engineering processes and typical careers						3		3	2	3	
Ability to research and compile a technical review on a chemical or environmental process including process block diagrams	2					2	3	2	2	2	1
Plant tours to environmental and chemical industries to familiarize students with day to day operations, safety considerations, and troubleshooting requirements.	2					3	1	2	2	2	
Familiarity to research and internship opportunities				1		1		1	1		
Ability to present research topics to a large audience within time allotted	2					2	3		1	2	2
Familiarity with library system for research topics and computer lab usage				1					1		2
Ability to use computer software for word processing, constructing tables and graphs, data analysis and making presentation slides.	2	1	2		2						3
Knowledge of latest developments in the field.						1		2	2	2	

Prepared by and date of preparation: K. Tam; May 9, 2006

Department, number and title of course: Department of Chemical and Environmental Engineering, CEE 125 – Analytical Methods for Chemical and Environmental Engineers

Required/Elective course: Required for the Chemical Engineering option

Catalog description: Topics include chromatographic separations, mass spectrometry, atomic absorption, and electrophoresis. Presents total carbon analysis as an introduction to analytical methods and their use in the chemical and environmental engineering fields

Prerequisite(s): CHEM 001C or consent of instructor.

Textbook(s) and/or other required material:
Environmental Chemical Analysis by Kebbekus and Mitra

Course objectives: Upon completion of this course, students should be able to:
1. Quantitatively prepare calibration solutions. Effective use of basic laboratory glassware including pipette, burette, mass balance, etc.
2. Calculate the precision and accuracy of a measurement technique.
3. Ability to analyze chemical samples using: gas chromatography (GC), high-performance liquid chromatography (HPLC), mass spectrometry (MS), UV-VIS spectrometer, ion chromatography (IC), atomic absorption (AA), total carbon analysis (TCA).
4. Identify the abilities and short-comings of the following techniques: GC, HPLC, MS, AA, UV-VIS, TCA, electrophoresis. Describe each instruments essential outputs.
5. Describe the principles of operation for GC, HPLC, IC, MS, AA, UV-VIS, TCA analysis.
6. Define chromatography. Describe chromatographic separation principles in terms of the Van Deemter curves. Identify the relative importance of each term for liquid, gas, and ion chromatography.
7. Define spectroscopy. Identify the regions of the spectrum. Describe the chemical property that each region analyzes for. Distinguish between absorption, fluorescence, phosphorescence
8. Prepare effective laboratory reports on research team outputs including abstracts, background, experimental set-up, and discussion of results.

Topics covered: Effective use of basic laboratory glassware; operation principles of GC, HPLC, Mass spectrometry, UV-VIS spectrometer, IC, AAS, and TCA; statistical techniques used to evaluate and process experimental data.

Class/laboratory schedule: Lecture, 2 hours; laboratory, 6 hours

Assessment methods:
Homework 10%
Midterm 20% (covers Weeks 1 through 5)
Lab 50% (Basic experiment: 20%, Instrumentation: 30%)
Final 20% (covers Weeks 6 through 10)

Contribution of course to meeting the professional component: This course introduces various analytical instruments which is essential to students who want to work in a laboratory. Identification and quantification of samples using instrumentation skills is one of the most important skills for chemical and environmental researchers.

Relationship of course to program outcomes: The contribution of CEE 125 to program outcomes (a)-(k) or (1) – (11) is summarized in the objective-outcome matrix table

Item	OUTCOME-RELATED LEARNING OBJECTIVES	OUTCOMES										
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	Quantitatively prepare calibration solutions. Effective use of basic laboratory glassware including pipette, burette, mass balance, etc.	2	3						1			
2	Calculate the precision and accuracy of a measurement technique.	2	3									
3	Ability to analyze chemical samples using: gas chromatography (GC), high-performance liquid chromatography (HPLC), mass spectrometry (MS), UV-VIS spectrometer, ion chromatography (IC), atomic absorption (AA), total carbon analysis (TCA).		3		2					2	3	
4	Identify the abilities and short-comings of the following techniques: GC, HPLC, MS, AA, UV-VIS, TCA, electrophoresis. Describe each instruments essential outputs.		2								3	
5	Describe the principles of operation for GC, HPLC, IC, MS, AA, UV-VIS, TCA analysis.		1					2			2	
6	Define chromatography. Describe chromatographic separation principles in terms of the Van Deemter curves. Identify the relative importance of each term for liquid, gas, and ion chromatography.		1					2	1			
7	Define spectroscopy. Identify the regions of the spectrum. Describe the chemical property that each region analyzes for. Distinguish between absorption, fluorescence, phosphorescence		1					2	1			
8	Prepare effective laboratory reports on research team outputs including abstracts, background, experimental set-up, and discussion of results.	1	3		3			3			3	

Prepared by and date of preparation: K. Na; May 9, 2006

Department, number and title of course: Department of Chemical and Environmental Engineering, CEE 132 – Green Engineering

Required/Elective course: Technical Elective for the Chemical and Biochemical Engineering options

Catalog description: An introduction to the design, commercialization, and use of feasible and economical processes and products that minimize risks to human health and the environment. Topics covered include environmental risk assessment, regulations, chemical process flow-sheet analysis for pollution prevention, product life-cycle assessment, and industrial ecology. Credit is awarded for only one of CEE 132 or CEE 232.

Prerequisite(s): senior standing or consent of instructor.

Textbook(s) and/or other required material:
Green Engineering, by D. Allen and D. Shonnard, Prentice Hall, 2002

Course objectives:
1. Familiarity with and ability to explain: environmental issues relating to global warming, smog formation, acidification, criteria air pollutants and effects on ecosystem.
2. Determine health risk (carcinogenic and non-carcinogenic) associated with contaminant exposure
3. Ability to research an environmental disaster and provide key details of the case, chemical involved, evidence of effects on human health and the environment, role of the chemical engineer and financial repercussions on the company. Individual oral presentation of topic.
4. Familiarity with the concepts of sustainability, sustainable energy processes and industrial cooperation in sustainability advancements. The latter subject is researched and presented in teams
5. Ability to conduct a literature search on a green engineering process and describe the green chemistry principles involved, the potential uses of the process, challenges to the process and prediction of success. Oral presentation by teams.
6. Familiarity with Type I and Type II assessments on a chemical process. Assess environmental hazards through TLVs, PELs, bioaccumulation of all material flows including fugitive emissions.
7. Familiarity with and ability to explain the concept of life cycle assessment (LCA), ability to define system boundaries for LCA and understanding of the ambiguities and limitations of LCA.
8. Familiarity with and ability to explain the 9 prominent federal environmental statutes.
9. Ability to evaluate the environmental fate of a chemical based on a chemical structure approach including concepts of octanol-water partition, oil sorption coefficients, melting and boiling point temperatures, vapor pressures and bioconcentration.

Topics covered: Environmental issues relating to global warming, smog formation, acidification, criteria air pollutants and effects on the ecosystem, personal impact assessment or footprint pertaining to energy and the environment, worldwide trends and options for sustainability and sustainable energy, carcinogenic and non-carcinogenic risk assessments, occupational and community exposure assessment, prominent federal environmental statutes, structure activity relationships for environmental fate assessments, green chemistry, Tier I and Tier II environmental performance tools, life cycle assessments, and environmental impact assessment.

Class/laboratory schedule: Lecture, 3 hours; discussion, 1 hour

Assessment methods: Homework 10%; Quizzes 20%; Presentations 40%; Final 30%

Contribution of course to meeting the professional component:

This course focuses on a number of environmental concepts including sustainability. Green engineering is still a relatively new and contemporary field. This course provides chemical and environmental engineering students a communicable knowledge of the impacts of the chemical processing industry wastes and emissions on the environment, the fate of pollution based on chemical structure, the risks associated with exposure, and the understanding of the life cycle analysis (LCA) technique and its ambiguities. Interrelationships between sustainable energy, global warming, smog formation with both global and societal impacts are highlighted. Students use their knowledge of science, math, and engineering to provide an analysis of any given chemical based on structure and determine its fate to air, water, soil, sediment, or biota, and its persistence. The latest tools available from the EPA website is featured in the assessment of chemicals and in analysis of emissions from tanks based on tank and chemical characterizations.

Through a series of three or four oral presentations, two of which are presented in different teams of two, students develop their ability to effectively communicate, to work in teams, and in understanding of the impacts of engineering solutions in a global and societal context. In the first presentation, students research and present case studies of environmentally catastrophic events or near misses from around the world. A critical evaluation of these historical events provides knowledge of proper engineering solutions, and a need to continually learn from errors of the past. The second presentation highlights contemporary technologies and works of industry toward the profitability of the sustainability trend. The third presentation features current green chemistry ideas that have been awarded the annual Presidential Green Chemistry Awards.

Relationship of course to program outcomes: The contribution of CEE 132 to program outcomes (a)-(k) or (1) – (11) is summarized in the objective-outcome matrix table

Objective-Outcome Matrix

Objective Addresses Outcome: 1-Slightly 2-Moderately 3-Substantially

Outcome Related Learning Objectives (See course objectives on previous page)	**Outcome 1**	**Outcome 2**	**Outcome 3**	**Outcome 4**	**Outcome 5**	**Outcome 6**	**Outcome 7**	**Outcome 8**	**Outcome 9**	**Outcome 10**	**Outcome 11**
Course Objective 1	2							2	1		
Course Objective 2	2				2	1		1			
Course Objective 3	3	1			1	2	3	2	1	2	1
Course Objective 4	1	1		2	1	2	3	1	1	1	1
Course Objective 5	3			3	2		3	2	1	3	2
Course Objective 6	2	2	2	3	2		3	2	1	2	2
Course Objective 7	2		1		1	1		2	1	1	1
Course Objective 8							3			1	
Course Objective 9	3				2						

Prepared by and date of preparation: K. Tam; May 9, 2006

Department, number and title of course: Department of Chemical and Environmental Engineering, CEE 135 – Chemistry of Materials

Required/Elective course: Technical Elective for the Chemical and Biochemical Engineering options

Catalog description: Introduction to the synthesis, structure, properties, and performance of modern materials. Topics include the science of materials, bonding and structure, the strength of materials, electrons in materials, semiconductors, superconductors, and optical properties of materials.

Prerequisite(s): CHEM 112A, MATH 009B

Textbook(s) and/or other required material:
Materials in Today's World by P. A. Thrower, (2nd Edition, Published by McGraw-Hill, 1996).

Course objectives: Upon completion of this course, students should be able to:

1. Understand chemical bonding, 5 types of bonds and their characteristics, hybridization, relationship between chemical bond and materials structure and properties
2. Understand amorphous and crystalline materials, crystal structure, close packed structures, relationship of bonding to crystal packing and properties
3. Describe the nature and effects of defects in solids, relationship of dislocations to materials properties and approaches to strengthening metals - elimination of dislocations, work hardening, precipitation hardening, grain refining
4. Describe the mechanical properties of materials - shear, tensile, yield, compressive stress, strain, stiffness, Young's modulus and use of alloys to improve properties for application
5. Describe basic polymers - types, synthesis and properties, co-polymers and applications
6. Understand the structure and properties of ceramics, strengthening of ceramics, composites
7. Demonstrate a fundamental knowledge of semiconductors and conductivity, photovoltaic cells, superconductors, optical and magnetic materials in relationship to electronic structure
8. Prepare and present a Power Point lecture on a topic relevant to the course

Topics covered:

1. Introduction to Materials Science (weeks 1 and 2)

- Classes of materials, - Bonding – covalent, ionic, metallic, hydrogen and van der Waals, - Crystal structures - amorphous and crystalline materials, - Defects in solids, motion of dislocations and how to control it, - Mechanical properties

2. Classes of Materials (weeks 3 and 4)

- Aluminum-lithium alloys, - Magnesium alloys, - HSLA steel, - Polymers – polyethylene, rubber, - Ceramics and composites

3. Electrons in Materials and Color (weeks 5 and 6)

- Elementary concepts of band structures of solids – insulators, semiconductors, metals, - Interaction of light with materials – electronic transitions in atoms, molecules and solids

4. Electrons in Semiconductors (weeks 7 and 8)

- Electronic structure of semiconductors, effect of dopants, basic devices, - Silicon solar cells, - Conductivity and superconductivity

5. Optical Behavior of Materials and Magnetism (weeks 9 and 10)

- Electromagnetic wave – reflection, refraction, absorption and transmission, - Optical Fibers – synthesis, total internal reflection, applications, - Magnetic Materials – soft and hard magnets, amorphous and ceramic magnets, magnetic domains, applications

Class/laboratory schedule: Lecture, 3 hours 20 minutes

Assessment methods:
Mid-term exam 33%; Presentations 33%; Final exam 33%

Contribution of course to meeting the professional component:
The course provides a basic understanding of materials science with a particular emphasis on the underlying chemistry and how this translates into structure and properties. The course introduces the students to the synthesis, structure, properties and performance of materials that are encountered in everyday life. The course covers historical perspective of the processing of materials and important developments of modern technologies and novel materials and the key role that these advances have played in advancing the civilization. The course covers three major classes of materials: metals, polymers and ceramics. Particular focus is placed on novel (nano)materials with applications in electronics, photonics, solar cells, structural materials and aerospace. At the end of the course, students are expected to be familiar with the fundamental physics and chemistry of the solid state as these disciplines relate to the understanding of the underlying mechanical, thermal, magnetic, semiconducting, conducting, superconducting, electronic and photonic properties of materials.
The students are required to prepare an oral in-class presentation on a topic in the chemistry of materials. The presentations are in the format of a PowerPoint lecture - 30 minutes in length and 10 minutes for questions and discussion. The objective of this assignment aims to provide basic skills in retrieving scientific information, organizing it into a coherent and comprehensive form, and the ability to communicate the data in a manner that is of interest to the audience. This assignment places a premium on the ability to design a presentation that brings together the important components in this course – the manner in which materials science translates into structure, properties and applications.
The presentations are graded and feedback provided according to the following criteria – relevance of the topic to the principles taught in the course, content, clarity of slide design, presentation skills and communication with the audience.

Relationship of course to program outcomes: The contribution of CEE 135 to program outcomes (a)-(k) or (1) – (11) is summarized in the objective-outcome matrix table

Objective-Outcome Matrix
Objective Addresses Outcome: 1-Slightly 2-Moderately 3-Substantially

Outcome Related Learning Objectives (See course objectives on previous page)	**Outcome 1**	**Outcome 2**	**Outcome 3**	**Outcome 4**	**Outcome 5**	**Outcome 6**	**Outcome 7**	**Outcome 8**	**Outcome 9**	**Outcome 10**	**Outcome 11**
Course Objective 1	3	1	2		1		1	1			
Course Objective 2	3		2		1		1	1			
Course Objective 3	3		1		3		1	2	1	1	1
Course Objective 4	3	2	3		3		1	2		2	
Course Objective 5	3		1		2	2	1	2	1	3	1
Course Objective 6	3		1		3		1	2	1	1	1
Course Objective 7	3		1		2		1	2	1	3	1
Course Objective 8	3		3	3	3	2	3	2	3	2	3

Prepared by and date of preparation: R. Haddon; May 9, 2006

Department, number and title of course: Department of Chemical and Environmental Engineering, CEE 158 – Professional Development for Engineers

Required/Elective course: Required Course

Catalog description: A review of various topics relevant to the professional development of chemical engineers. Topics include career paths, interview strategies, professional registration and preparation for certification examinations, ethics, risk management and environmental health and safety, and regulatory issues.

Prerequisite(s): Upper Division Standing

Textbook(s) and/or other required material:
Career Management for Scientists and Engineers by John K. Borchardt Oxford University Press, 0841235252
The Healthy Mind Healthy Body Handbook by Sobel and Ornstein Time Life Medical, 1575770326
Ethics in Engineering Practice and Research by Whitbeck Cambridge University Press, 0521479444
FE Supplied Reference Handbook © 2005 shop.ncees.org, 1-932613-19-6
FE Review Manual by Michael R. Lindeburg © 2004 pi2pass.com 1-888577-53-3

Course objectives: Upon completion of this course, students should be able to:
1. Plan for the future, know about financial options, and begin thinking about retirement plans
2. Establish a path forward for continuing professional development and life-long learning, preparing for the changing job environment
3. Identify and practice techniques for taking care of "self"
4. Develop answers to common interview questions
5. Prepare a resume for a professional job search
6. Discuss the NCEES ethical guidelines and their implementation into modern engineering practice
7. Prepare for graduate school and/or the FE/EIT exam.
8. Demonstrate effective communication skills including team building, conflict resolution, role playing, and technical writing

Topics covered:
This course focused on the skills necessary for an engineer to have a successful professional career. Topics include self reflection on goals and desired outcomes from a career, planning for future financial independence, planning for life long learning, preparation for interviewing and job search, preparation for graduate school and/or the FE/EIT examination, and applying moral theories and reasoning to professional and personal ethics. Students also advance team building, conflict resolution, and role playing skills during various in class and independent studies.

Class/laboratory schedule: Lecture, 3 hours;

Assessment methods:
Each of the first eight assignments will be graded on a - √ + system. Any grade below a + requires that you redo the assignment for your portfolio. Both the original version and the final version should be included in the portfolio. Comments for improvement will be provided on each assignment. Your portfolio is to be a folder that contains all of your work in the class as well as anything else that you think helps prove your grade. The first section of your portfolio should be a written justification of the

grade you think you deserve in the course and why. During the week of final examinations, you will need to schedule a one on one appointment with me to discuss your performance in the course and the grade that I am going to assign. If we disagree, you can attempt to persuade me to give you a higher grade. You will know your final grade in the course before you leave my office. Note that these documents should help you whether you decide to pursue an advanced degree or go in to industry. Your portfolio is a chance for you to provide a detailed document demonstrating the quality of work you are capable of performing.

Contribution of course to meeting the professional component:
This course includes significant discussion of the impact of moral reasoning on engineering decision making. It also rounds out the students' education by providing general education topics to help the students have a successful career rather than a job in engineering.

Relationship of course to program outcomes: The contribution of CEE 158 to program outcomes (a)-(k) or (1) – (11) is summarized in the objective-outcome matrix table

Objective-Outcome Matrix
Objective Addresses Outcome: 1-Slightly 2-Moderately 3-Substantially

Outcome Related Learning Objectives	**Outcome 1**	**Outcome 2**	**Outcome 3**	**Outcome 4**	**Outcome 5**	**Outcome 6**	**Outcome 7**	**Outcome 8**	**Outcome 9**	**Outcome 10**	**Outcome 11**
Plan for the future, know about financial options, and begin thinking about retirement plans	1	0	0	0	1	1	0	1	1	2	1
Establish a path forward for continuing professional development and life-long learning, preparing for the changing job environment	0	0	0	1	0	3	0	0	3	0	0
Identify and practice techniques for taking care of "self"	0	0	0	1	0	1	0	3	0	0	0
Develop answers to common interview questions	0	0	0	1	0	0	1	0	0	1	0
Prepare a resume for a professional job search	0	0	0	0	0	0	1	0	0	0	0
Discuss the NCEES ethical guidelines and their implementation into modern engineering practice	0	0	0	1	1	3	1	3	0	2	1
Prepare for graduate school and/or the FE/EIT exam.	3	1	0	0	3	0	0	3	0	0	1
Demonstrate effective communication skills including team building, conflict resolution, role playing, and technical writing	0	0	0	3	0	1	3	1	0	1	0

Prepared by and date of preparation: K. Kauffman; May 9, 2006

Department, number and title of course: Department of Chemical and Environmental Engineering ENGR 118 – Engineering Modeling & Analysis

Required/Elective course: Required Course

Catalog description: Covers the formulation of mathematical models for engineering systems; applying mass, momentum, and energy balances to derive governing differential equations; solving equations with the use of spreadsheets and other software packages; and fitting linear and nonlinear models to experimental data. Credit is awarded for only one of ENGR 118 or ME 118.

Prerequisite(s): CHEM 001A or CHEM 01HA; CS 010; MATH 046; PHYS 040B; or consent of instructor.

Textbook(s) and/or other required material:
Advanced Engineering Mathematics Scheid, Numerical Analysis by Zill & Cullen 2nd Ed

Course objectives: Upon completion of this course, students should be able to:

1. Accurately numerically solve, evaluate, and/or approximate derivatives, integrals, and differential equations
2. Use appropriate numerical methods to solve for roots of linear and nonlinear functions, linear and nonlinear ODEs and PDEs, systems of equations, and for optimal conditions
3. Use appropriate numerical techniques to interpolate or curve fit as needed
4. Evaluate complex integrations and differentiations in one, two and three dimensions
5. Analytically solve systems of linear equations (both algebraic and ordinary differential equations)
6. Apply common analytical solution techniques to ordinary and partial differential equations
7. Propagate error from experimental data sets and estimate key descriptive statistics from data
8. Apply techniques used in this class to various relevant problems from the chemical and physical sciences
9. Understand the significance of the integrity oath which they sign before each examination
10. Work together with other students in class to prepare solutions to example problems and correct those solutions that are presented incorrectly. Present their results in an efficient and effective manner

Topics covered:
This course reviewed all mathematical concepts covered during the first two years of the CHE/ENVE curriculum and applied them to realistic chemical engineering situations. Students carried out computer simulations to practice the numerical techniques and relate the answers found numerically to analytical techniques. Students applied the various concepts to design of experiments; modeling of chemical, biological, and environmental processes; and to evaluating various potential situations to make more informed decisions.

Class/laboratory schedule: Lecture, 4 hours; discussion, 1 hour.

Assessment methods:

Midterm Examinations (4)	10% Each	40%
Take Home Final Examination	25%	25%
Homework, Projects, Programming	25%	25%
Quizzes, Attendance, Participation	10%	10%

Contribution of course to meeting the professional component:
This course bridges the one year of mathematics and basic sciences by revisiting the mathematical concepts in light of how they are used for the engineering design and decision making processes. Students are also exposed to ethical considerations and the consequences for violating those considerations through the use of an Oath of Integrity that must be signed for each examination or project.

Relationship of course to program outcomes: The contribution of ENGR 118 to program outcomes (a)-(k) or (1) – (11) is summarized in the objective-outcome matrix table

Objective-Outcome Matrix
Objective Addresses Outcome: 1-Slightly 2-Moderately 3-Substantially

Outcome Related Learning Objectives	Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5	Outcome 6	Outcome 7	Outcome 8	Outcome 9	Outcome 10	Outcome 11
Accurately numerically solve, evaluate, and/or approximate derivatives, integrals, and differential equations	3				1				1		3
Use appropriate numerical methods to solve for roots of linear and nonlinear functions, linear and nonlinear ODEs and PDEs, systems of equations, and for optimal conditions	3				1						3
Use appropriate numerical techniques to interpolate or curve fit as needed	3				1						3
Evaluate complex integrations and differentiations in one, two and three dimensions	3				1						1
Analytically solve systems of linear equations (both algebraic and ordinary differential equations)	3				1						1
Apply common analytical solution techniques to ordinary and partial differential equations	3				1						1
Propagate error from experimental data sets and estimate key descriptive statistics from data	3	3			1				1		3
Apply techniques used in this class to various relevant problems from the chemical and physical sciences	3	2	1	1	3			2	1	1	3
Understand the significance of the integrity oath which they sign before each examination						2		1	1	1	
Work together with other students in class to prepare solutions to example problems and correct those solutions that are presented incorrectly. Present their results in an efficient and effective manner		1		1			3	1	1		3

Prepared by and date of preparation: K. Kauffman; May 30, 2006

Department, number and title of course: Department of Chemical and Environmental Engineering, CHE 100 – Engineering Thermodynamics

Required/Elective course: Required Course

Catalog description: An introduction to engineering thermodynamics with emphasis on chemical and environmental engineering systems. Topics include concepts of equilibrium, temperature, and reversibility; the first law and concept of energy; and the second law and concept of entropy. Also examines equations of state, thermodynamic properties, and engineering applications used in the analysis and design of closed and open systems. Credit is awarded for only one of CHE 100 or ME 100A.

Prerequisite(s): CHEM 001C, MATH 010A, PHYS 040B; or consent of instructor.

Textbook(s) and/or other required material:
Introduction to Chemical Engineering Thermodynamics, 7th ed., by J.M. Smith, H.C. Van Ness and M.M. Abbott, McGraw-Hill, 2005.

Course objectives: Upon completion of this course, students should be able to:

1. Introduce the issues of thermodynamics
2. Apply energy balance in terms of internal energy and enthalpy; apply the 1st law for open systems and flow processes
3. Find or calculate thermodynamic properties of ideal gases and real matters including steam
4. Apply the problem-solving skills
5. Explain in none technical terms 1) Clausius' statement of the 2nd law and 2) Carnot Cycle
6. Apply the 2nd law for flow processes
7. Perform thermodynamic calculations for steady-state engineering devices and thermodynamic cycles
8. Apply a general procedure for the calculation of the changes in thermodynamic properties using an equation of state

Topics covered: An introduction to engineering thermodynamics with emphasis on chemical and environmental engineering systems. Topics include concepts of equilibrium, temperature, and reversibility; the first law and concept of energy; and the second law and concept of entropy. Also examines equations of state, thermodynamic properties, and engineering applications used in the analysis and design of closed and open systems.

Class/laboratory schedule: Lecture, 3 hours; discussion, 1 hour

Assessment methods:

HW 25%	80+ --> A
Midterms 40%	70+ --> B
Final 35%	60+ --> C
	50+ --> D

Contribution of course to meeting the professional component:
This course serves as an introduction to engineering thermodynamics. The concepts introduced provided the basis to assess the energy requirements and feasibility of the design. A few selected examples from the chemical and environmental industries were used to demonstrate the practical utility of the concept.

Relationship of course to program outcomes: The contribution of CHE 100 to program outcomes (a)-(k) or (1) – (11) is summarized in the objective-outcome matrix table

Objective-Outcome Matrix
Objective Addresses Outcome: 1-Slightly 2-Moderately 3-Substantially

Outcome Related Learning Objectives	Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5	Outcome 6	Outcome 7	Outcome 8	Outcome 9	Outcome 10	Outcome 11
To introduce the issues of thermodynamics						1		2	1	1	
Apply energy balance in terms of internal energy and enthalpy; apply the 1st law for open systems and flow processes	3										
Find or calculate thermodynamic properties of ideal gases and real matters including steam	3				1						
Apply the problem-solving skills				3	3		2				
Explain in none technical terms 1) Clausius' statement of the 2nd law and 2) Carnot Cycle							3			1	
Apply the 2nd law for flow processes	3										
To perform thermodynamic calculations for steady-state engineering devices and thermodynamic cycles	3		3								2
To apply a general procedure for the calculation of the changes in thermodynamic properties using an equation of state	3										
To introduce the issues of thermodynamics						1		2	1	1	
To apply energy balance in terms of internal energy and enthalpy; apply the 1st law for open systems and flow processes	3										

Prepared by and date of preparation: W. Chen; May 9, 2006

Department, number and title of course: Department of Chemical and Environmental Engineering, CHE 102 – Catalytic Reaction Engineering

Required/Elective course: Technical Elective for the Chemical Engineering option

Catalog description: Principles of surface reactions and heterogeneous catalysis. Catalyzed reaction kinetics, heterogeneous reactions, diffusion and heterogeneous catalysis, analysis and design of heterogeneous reactors.

Prerequisite(s): CHE 122 or consent of instructor.

Textbook(s) and/or other required material:
Principles and Practice of Heterogeneous Catalysis by Thomas and Thomas, VCH, 1997
Fundamentals of Chemical Reaction Engineering by Davis and Davis, McGraw-Hill, 2003.

Course objectives:

1. In one or two sentences, explain in jargon-free language: catalyst, selectivity, activity, durability, active component, support, dispersion, particle size, surface area, pore size, size distribution, chemisorption, physisorption, langmuir isotherm, BET method, monolayer adsorption, multilayer adsorption, Thiele modulus, effectiveness factor.
2. Based on chemisorption data to calculate metal surface area, metal particle size and dispersion. Experimental procedures and techniques for treating chemisorption.
3. Based on physisorption data to calculate surface area, pore size and pore size distribution of porous support. Recognize the importance of these parameters for designing heterogeneous catalysis system.
4. An ability to derive kinetics based on the elementary steps involving adsorption, surface reaction, and desorption.
5. An ability to handle effect of external mass transfer and pore diffusion in a heterogeneous catalysis system and be able to use effectively the mass transfer coefficient and effectiveness factor and know how to obtain these numbers
6. Good knowledge of current catalysis topics through case studies on automotive catalysis and fuel cell catalysis (team study)
7. An ability to do efficient literature search on a given research topic such as fuel processing steps for fuel cells (team)
8. An ability to work effectively in a team for a particular catalysis topic, an ability to summarize a topic based on his/her own reading into a concise technical report with references, and an ability to deliver the report effectively in a oral TEAM presentation

Topics covered:

1. Introduction of heterogeneous catalysis (Week 1 and 2)

Heterogeneous catalysis and its major applications
Historical perspective of heterogeneous catalysis
Catalyst selectivity, activity, stability

2. Fundamentals of heterogeneous catalyst: Supported metal catalyst as a model system (Week 3-5)

Catalyst loading, its calculation, and measurement
Catalyst dispersion: chemisorption (Langmuir)
Support surface area: physisorption (BET) or mercury penetration

Support pore size, pore volume and pore size distribution: physisorption (BET) and mercury penetration

3. Kinetics of heterogeneous reactions (Week 6 and7)

Reaction steps, surface reactions, active site, reaction rate formulation

4. Mass transfer in heterogeneous catalysis (Week 7-9)

External mass transfer, diffusion in pores, effectiveness factor, Thiele modulus

5. Automotive catalysis (Week 9)

Three-way catalyst, catalyst, support, reactor design

6. Fuel cell catalysis (Week 9 and 10)

Proton exchange membrane fuel cell systems: structures, electrode catalysis, reformers, and current issues

Class/laboratory schedule: Lecture, 3 hours; discussion, 1 hour

Assessment methods:

Homework 25%
Midterm 30%
Final 45%

Contribution of course to meeting the professional component:

This course teaches the fundamentals of heterogeneous catalysis. It also introduces the most contemporary topics in catalysis, e.g., automotive catalysis and fuel cell catalysis. To emphasize team work, teams of 3-4 students are formed at the beginning of the quarter and each team assigned a catalysis topic. They will begin with literature search of their topic and start immediately to write short referenced essays in the selected topic. The papers will be reviewed and graded by the instructor and feedbacks will be given to the team for revision. This is an on-going process of the whole quarter and at the end of the quarter, each team will do a 10-15 minutes presentation on their project that is a translated version of their essays. Design components are emphasized in these projects. The homework assignments are mostly from published articles and are open-ended problems.

Relationship of course to program outcomes: The contribution of ChE102 to program outcomes (a)-(k) or (1) – (11) is summarized in the objective-outcome matrix table

Objective-Outcome Matrix

Objective Addresses Outcome: 1-Slightly 2-Moderately 3-Substantially

Outcome Related Learning Objectives (See course objectives on previous page)	Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5	Outcome 6	Outcome 7	Outcome 8	Outcome 9	Outcome 10	Outcome 11
Course Objective 1	3	0	0	0	0	0	3	0	0	0	0
Course Objective 2	3	2	0	0	2	0	1	0	0	0	0
Course Objective 3	3	2	0	0	2	0	1	0	0	0	0
Course Objective 4	3	2	0	0	2	0	0	0	0	0	0
Course Objective 5	3	2	2	0	3	0	0	0	0	0	0
Course Objective 6	1	1	1	3	3	2	2	3	3	3	1
Course Objective 7	3	1	2	3	3	2	2	3	3	3	2
Course Objective 8	3	2	3	3	3	2	3	3	3	3	3

Prepared by and date of preparation: Y. Yan; May 9, 2006

Department, number and title of course: Department of Chemical and Environmental Engineering, CHE 110A – Chemical Process Analysis – Energy Balance

Required/Elective course: Required Course

Catalog description: Introduces the principles of conservation of mass in chemical process systems. Topics include the development of steady-state mass balances, and application of mass balances to existing industrial processes.

Prerequisite(s): CHEM 001C, MATH 009C, PHYS 040B; or consent of instructor.

Textbook(s) and/or other required material:
Elementary Principles of Chemical Processes; Richard M. Felder, R. W. Rousseau, 3rd Edition, John Wiley & Sons, 2000.

Course objectives:
1. Introduction to engineering calculations and process variables
2. Set up balance equations for non reactive systems and able to apply them for system analysis and design
3. Set up balance equations for reactive systems and able to apply them for system analysis and design
4. Extend the mass balance analysis to gas phase systems
5. Incorporation of multi-phase systems into the mass balance analysis
6. Setup balance equations for different chemical engineering processes

Topics covered: Introduces the principles of conservation of mass in chemical process systems. Topics include the development of steady-state mass balances, and application of mass balances to existing industrial processes.

Class/laboratory schedule: Lecture, 2 hours; discussion, 1 hour

Assessment methods:

Homework	25%	85+ --> A
Midterms	40%	70+ --> B
Final	35%	60+ --> C
		50+ --> D

Contribution of course to meeting the professional component:
This course serves as an introduction to chemical engineering, providing the importance of mass balance on process design and analysis. More importantly, practical examples involving different unit operations were provided as an introduction to the chemical engineering industry.

Relationship of course to program outcomes: The contribution of CHE 110A to program outcomes (a)-(k) or (1) – (11) is summarized in the objective-outcome matrix table

Objective-Outcome Matrix

Objective Addresses Outcome: 1-Slightly 2-Moderately 3-Substantially

Outcome Related Learning Objectives	Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5	Outcome 6	Outcome 7	Outcome 8	Outcome 9	Outcome 10	Outcome 11
Introduction to engineering calculations and process variables	3						2			2	
Set up balance equations for non reactive systems and able to apply them for system analysis and design	3	1	1		2	1	2	1			2
Set up balance equations for reactive systems and able to apply them for system analysis and design	3	1	1		2	1	2	1			2
Extend the mass balance analysis to gas phase systems	3	1	1		2	1	2	1			2
Incorporation of multi-phase systems into the mass balance analysis	3	1	1		2	1	2	1			2
Setup balance equations for different chemcial engineering processes	2		2				2		1		

Prepared by and date of preparation: W. Chen; May 9, 2006

Department, number and title of course: Department of Chemical and Environmental Engineering, CHE 110B – Chemical Process Analysis – Energy Balance

Required/Elective course: Required Course

Catalog description: Applies principles of conservation of energy to chemical process systems. Topics include the development of steady-state and unsteady-state energy balances, and combined mass and energy balances in industrial processes.

Prerequisite(s): CHE 110A; or consent of instructor

Textbook(s) and/or other required material:
Elementary Principles of Chemical Processes; Richard M. Felder, R. W. Rousseau, 3rd Edition, John Wiley & Sons, 2000.

Course objectives:
1. Familiarity with and ability to perform unit conversions related to basic fluid properties, fluid statics, and fluid mechanic relationships
2. Ability to present solutions, calculations, and results in a logical, readable format
3. Ability to apply mass balance to multiphase systems
4. Ability to apply energy balance to non-reactive systems
5. Ability to apply energy balance to reactive systems
6. Ability to solve transient mass and energy balance

Topics covered:

WEEK	TOPIC	READING ASSIGNMENT
1-2	Multiphase Systems	Chapter 6
2-3	Introduction to Energy Balance	Chapter 7
3-6	Energy Balance (Non-reactive Systems)	Chapter 8
6-9	Energy Balance (Reactive Systems)	Chapter 9
9-10	Transient Mass and Energy Balances	Chapter 11

Class/laboratory schedule: Lecture, 2 hours; discussion, 1 hour

Assessment methods:
Homework 20% 84+ → A, 72+ → B, 60+→ C, 50+ → D
Midterms 30%
Final 50 %

Contribution of course to meeting the professional component:
This course teaches the application of energy conversion to chemical and environmental process systems. Topic includes the development of steady-state and unsteady-state energy balances, and combined mass and energy balances in industrial process. More importantly, practical examples involving different unit operations were provided as an introduction to the chemical and environmental engineering industry. The homework assignments are mostly practical problem from textbook.

Relationship of course to program outcomes: The contribution of CHE 110B to program outcomes (a)-(k) or (1) – (11) is summarized in the objective-outcome matrix table

Objective-Outcome Matrix
Objective Addresses Outcome: 1-Slightly 2-Moderately 3-Substantially

Outcome Related Learning Objectives	**Outcome 1**	**Outcome 2**	**Outcome 3**	**Outcome 4**	**Outcome 5**	**Outcome 6**	**Outcome 7**	**Outcome 8**	**Outcome 9**	**Outcome 10**	**Outcome 11**
Familiarity with and ability to perform unit conversions related to basic fluid properties, fluid statics, and fluid mechanic relationships	2	1		1							
Ability to present solutions, calculations, and results in a logical, readable format		1			1	2	3				1
Ability to apply mass balance to multiphase systems	3		3		3						3
Ability to apply energy balance to non-reactive systems	3		3		3						3
Ability to apply energy balance to reactive systems	3		3		3						3
Ability to solve transient mass and energy balance	3		3		3						3

Prepared by and date of preparation: N. Myung; May 9, 2006

Department, number and title of course: Department of Chemical and Environmental Engineering, CHE 114 – Applied Fluid Mechanics

Required/Elective course: Required Course

Catalog description: An introduction to fluid statics, fluid flow, flow of compressible and incompressible fluids in conduits and open-channel flow, flow past immersed bodies, transportation and metering of fluids, and agitation and mixing of liquids. Credit is awarded for only one of CHE 114 or ME 113.

Prerequisite(s): MATH 010A, MATH 046; or consent of instructor.

Textbook(s) and/or other required material:
Fluid Mechanics for Chemical Engineers by Noel de Nevers 3rd Edition, McGraw Hill

Course objectives:

1. Familiarity with and ability to perform unit conversions related to basic fluid properties, fluid statics, and fluid mechanic relationships
2. Ability to present solutions, calculations, and results in a logical, readable format
3. Ability to apply mass balance and energy balance to appropriate system for design of hydraulic structures
4. Ability to apply Bernoulli's equation to appropriate systems for design of hydraulic structures
5. Ability to apply fluid friction to appropriate systems for design of open and close system
6. Ability to apply differential method for solution of momentum balances with Newton's second law
7. Ability to derive basic relations such as Hagen-Poiseuille equation from Navier Stokes equations of motion
8. Understanding of the principals of operation for turbomachinery - pumps, compressors, turbines
9. Ability to predict fluid mechanics behavior from tabulated experimental data via plotting, regression analyses, and interpolation/extrapolation

Topics covered:

WEEK	TOPIC	READING ASSIGNMENT
1-2	Properties of Fluids	Chap. 1
	Fluid Statics	Chap. 2
	Mass and Energy Balance	Chap. 3
3.-4	The 1st law of thermodynamics	Chap. 4
	Bernoulli's Equation (BE)	Chap. 5
	Applications and Limitation of BE	Chap. 5
	Fluid Friction in Steady, One-Dimensional Flow	Chap. 6
5-6	Momentum Balance	Chap. 7
	1-D, High Velocity Gas Flow	Chap. 8
	Models, Dimensional Analysis, And Dimensionless Number	Chap. 9
7-8	Pumps, Compressors, and Turbines	Chap. 10
	Flow through Porous Media	Chap. 11
	Gas-Liquid Flow	Chap. 12
9-10	Two- and Three-Dimensional Fluid Mechanics	Chap. 15

Potential Flow	Chap. 16
The Boundary Layer	Chap. 17
Turbulence	Chap. 18

Class/laboratory schedule: Lecture, 3 hours; discussion, 1 hour

Assessment methods:

Homework	20%	84+ → A, 72+ → B, 60+→ C, 50+ → D
Midterms	40%	
Final	40%	

Contribution of course to meeting the professional component:
This course, taken both by chemical and environmental engineering students, is one of the three courses focusing on transport phenomena. This course teaches the fundamental of fluid mechanics for both chemical and environmental engineering students. During the course, fluid statics, flow of compressible and incompressible fluids in close-channel and open-channel, flow past immersible bodies, transportation and metering of fluids, and agitation and mixing of liquid are covered. More importantly, practical examples involving different unit operations were provided as an introduction to the chemical engineering industry. The homework assignments are mostly from practical problem from textbook. Laboratory exercises in fluidic mechanics are covered in CHE/ENVE 160A.

Relationship of course to program outcomes: The contribution of CHE 114 to program outcomes (a)-(k) or (1) – (11) is summarized in the objective-outcome matrix table

Objective-Outcome Matrix

Objective Addresses Outcome: 1-Slightly 2-Moderately 3-Substantially

Outcome Related Learning Objectives (See course objectives on previous page)	**Outcome 1**	**Outcome 2**	**Outcome 3**	**Outcome 4**	**Outcome 5**	**Outcome 6**	**Outcome 7**	**Outcome 8**	**Outcome 9**	**Outcome 10**	**Outcome 11**
Course Objective 1	2	1		1							
Course Objective 2		1			1	2	3				1
Course Objective 3	3		3		3						3
Course Objective 4	3		3		3						3
Course Objective 5	3		3		3						3
Course Objective 6	3		3		3						3
Course Objective 7	3		3		3						3
Course Objective 8	2				2						
Course Objective 9	3	2	2		3			3		3	

Prepared by and date of preparation: N. Myung; May 30, 2006

Department, number and title of course: Department of Chemical and Environmental Engineering, CHE 116 – Heat Transfer

Required/Elective course: Required Course

Catalog description: An analysis of heat transfer for Chemical Engineering and Environmental Engineering majors. Topics include steady- and unsteady-state heat conduction, forced convection, basic radiation heat transfer, and design of heat exchangers. Credit is awarded for only one of CHE 116 or ME 116A.

Prerequisite(s): CHE 100, CHE 114; or consent of instructor.

Textbook(s) and/or other required material:
Heat Transfer by J.P. Holman Ninth Edition, McGraw Hill

Course objectives:

1. Ability to identify and evaluate plane wall, radial, and spherical steady state conduction systems
2. Evaluation of resistances to heat transfer in composite and finned systems. Composite systems in application to construction design.
3. Ability to solve heat transfer problems in two dimensional states
4. Ability to determine transient conduction in planar, cylindrical and spherical coordinates
5. Understanding and applying fluid mechanics to forced convection heat transfer
6. Understanding heat transfer concepts in free convection and phase changing systems
7. Understanding benefits and limitations of several types of heat exchanger systems
8. Ability to design a heat exchanger system to accommodate specified conditions and provide results in a technical report
9. Ability to solve heat transfer problems involving radiation

Topics covered: Steady-state conduction-one dimension, Steady-state conduction-multiple dimensions, Unsteady-state conduction, Principles of convection, Empirical and practical relations for forced-convection heat transfer, Natural convection, Radiation heat transfer and Heat exchangers.

Class/laboratory schedule: Lecture, 3 hours; discussion, 1 hour.

Assessment methods:

Homework, quizzes, design project, class participation	20%
Midterms (2)	40%
Final	40%

Grading Scheme: 90+ A+, 85-89 A; 80-84 A-, 75-79 B+, 70-74 B, 65-69, B-, 60-64 C+, 55-59 C, 50-54 C-, 45-49 D+, 40-44 D

Contribution of course to meeting the professional component: This course, taken both by chemical and environmental engineering students, is one of the three courses focusing on transport phenomena. The course contributes to the engineering science and engineering design components of the Chemical Engineering and Environmental Engineering curriculum. Students learn the mechanism and calculation of heat transfer by the three modes, and apply them to design heat transfer equipment. The students work on design of a shell-and-tube heat exchanger to perform a specified task.

Homework, classroom sample problems, and exams challenge students in their problem solving skills. Laboratory exercises in heat transfer are covered in CHE/ENVE 160B.

Relationship of course to program outcomes: The contribution of CHE 116 to program outcomes (a)-(k) or (1) – (11) is summarized in the objective-outcome matrix table

Objective-Outcome Matrix

Objective Addresses Outcome: 1-Slightly 2-Moderately 3-Substantially

Outcome Related Learning Objectives	**Outcome 1**	**Outcome 2**	**Outcome 3**	**Outcome 4**	**Outcome 5**	**Outcome 6**	**Outcome 7**	**Outcome 8**	**Outcome 9**	**Outcome 10**	**Outcome 11**
Ability to identify and evaluate plane wall, radial, and spherical steady state conduction systems	3				3						1
Evaluation of resistances to heat transfer in composite and finned systems. Composite systems in application to construction design.	3		2		3						1
Ability to solve heat transfer problems in two dimensional states	3		2		3						2
Ability to determine transient conduction in planar, cylindrical and spherical coordinates	3		1		3						1
Understanding and applying fluid mechanics to forced convection heat transfer	3	1	1		3						1
Understanding heat transfer concepts in free convection and phase changing systems	3	1	1		3						1
Understanding benefits and limitations of several types of heat exchanger systems	3	2	2		2			1	1	1	2
Ability to design a heat exchanger system to accommodate specified conditions and provide results in a technical report	3	2	3	1	3	2	3	1	1		3
Ability to solve heat transfer problems involving radiation	3	1	1		3						1

Prepared by and date of preparation: A. Mulchandani; May 30, 2006

Department, number and title of course: Department of Chemical and Environmental Engineering, CHE 117 - Separation Processes

Required/Elective course: Required Course

Catalog description: Fundamental concepts and practical techniques for designing equipment based on equilibrium stage processes such as gas-liquid absorption, distillation, liquid-liquid extraction, solid-liquid extraction, humidification, drying, and membrane processes.

Prerequisite(s): CHE 130/ENVE 130 (may be taken concurrently), CHE 116, CHE 120; or consent of instructor

Textbook(s) and/or other required material:
Unit Operations of Chemical Engineering by McCabe, Smith and Harriott, McGraw Hill

Course objectives:
1. Broad overview of industrial separation processes. Understand their mechanisms and principles.
2. Know how to apply numerical and graphical techniques to analyze separation processes in terms of equilibrium stage.
3. Know how to use basic thermodynamic laws for phase equilibrium, and mass transfer concepts for the design of separation processes.
4. Acquire basic skills that enable sizing of absorbers, distillation towers, dryers, and liquid-liquid extraction units
5. Know how to use literature (correlations, graphs, vendor information etc.) to estimate the necessary parameter for dimensioning.
6. To practice problem solving skills (homework, sample problems)
7. Acquire basic knowledge of equipment used in chemical process separations
8. Learn how to use a commercial computer aided design software (SuperPro Designer) for unit operation design, and understand basic theory "behind the code"

Topics covered: Gas absorption and stripping (theory, design, equipment, operation of gas absorber), Distillation (theory, design and sizing, azeotropic distillations), Drying (focus on determination of drying time, not on equipment), Leaching and liquid liquid extraction (theory, design and sizing, equipment), Membrane separations are only covered if time allows. Basic working knowledge of SuperPro Designer (computer aided design software).

Class/laboratory schedule: Lecture, 3 hours; discussion, 1 hour

Assessment methods:
Final 50%
Mid terms 30%
Homework and quizzes 20% if min 35% (combined quizzes and homework) is not reached final grade for the class is F

Contribution of course to meeting the professional component:
This course focuses on selected unit operations for chemical engineers. The course requires integration of mass (and sometimes heat and momentum) transfer concepts into systems design to reach a desired objective (the separation of a given mixture). Students practice numerical methods, iterative problem

solving. Some projects require evaluation and/or comparison of several options. Homework, classroom sample problems, and exams challenge students in their problem solving skills. Many problems are open-ended and can be solved using different methods. The course also integrates economical factors and constraints, and an introduction to a professional design software (SuperPro Designer). Reprints of Chemical Engineering Progress are given to the students so that they can develop an appreciation of contemporary issues.

Relationship of course to program outcomes: The contribution of CHE 117 to program outcomes (a)-(k) or (1) – (11) is summarized in the objective-outcome matrix table

Objective-Outcome Matrix

Objective Addresses Outcome: 1-Slightly 2-Moderately 3-Substantially

Outcome Related Learning Objectives	**Outcome 1**	**Outcome 2**	**Outcome 3**	**Outcome 4**	**Outcome 5**	**Outcome 6**	**Outcome 7**	**Outcome 8**	**Outcome 9**	**Outcome 10**	**Outcome 11**
Broad overview of industrial separation processes. Understand their mechanisms and principles.	3		2		1	2		3		2	2
Know how to apply numerical and graphical techniques to analyze separation processes in terms of equilibrium stage.	3	1	2		3					2	
Know how to use basic thermodynamic laws for phase equilibrium, and mass transfer concepts for the design of separation processes.	3		1		3			1			
Acquire basic skills that enable sizing of absorbers, distillation towers, dryers, and liquid-liquid extraction units	3		3		3			3	2	2	
Know how to use literature (correlations, graphs, vendor information etc.) to estimate the necessary parameter for dimensioning.	2	1	1		2		1	3			
To practice problem solving skills (homework, sample problems)	3	1	1	3	3		2			1	1
Acquire basic knowledge of equipment used in chemical process separations	1		1		1						
Learn how to use a commercial computer aided design software (SuperPro Designer) for unit operation design, and understand basic theory "behind the code"	1	1	3	1	3	1		3	2	3	3

Prepared by and date of preparation: M. Deshusses; May 23, 2006

Department, number and title of course: Department of Chemical and Environmental Engineering CHE 118 – Process Dynamics and Control

Required/Elective course: Required Course

Catalog description: Fundamentals of process control. Feedback and feed forward control of dynamic processes. Frequency response analysis. Introduction to multivariable control.

Prerequisite(s): CHE 117, CHE 122, ENGR 118; or consent of instructor.

Textbook(s) and/or other required material:
Process Dynamics, Modeling, & Control by Ogunnaike & Ray

Course objectives: Upon completion of this course, students should be able to:

1. Derive appropriate differential equations to describe process dynamics from fundamental principles (e.g., mass balance, energy balance, species balance, etc)
2. Use the equations derived in #1 to formulate models of appropriate complexity and relevance for process control, stability analysis, and dynamic analyses
3. Identify the order, stability, and approximate dynamic response of a linear model based on analysis of the transfer function and/or of experimental data
4. Based on data, estimate the parameters of a model suitable for process control purposes
5. Simulate open and closed loop dynamic behavior in Simulink (e.g., construct Simulink based models, determine appropriate parameters and constraints for the simulations, and analyze the resulting behavior)
6. Design control mechanisms to stabilize unstable processes.
7. Prepare technical communications of varying complexities based on work in process dynamics and control
8. Design single input, single output control loops for common processes in order to meet a desired need.
9. Design preliminary control loops for advanced control issues (model based control, MIMO, cascade, etc)
10. Incorporate process control for safety, environmental compliance, and profit maximization

Topics covered:
Application of process modeling to the development of linear models for process control purposes, including the evaluation of the appropriate degree of complexity for a given situation. Students characterize the response of a process and then design controllers to achieve a desired outcome with the given process. A hands-on computer laboratory is included, where the students conduct extensive simulations of various processes. Advanced control topics are also included.

Class/laboratory schedule: Lecture, 3 hours; discussion, 1 hour.

Assessment methods:
Homework is graded on a 0, 1, 2, 4 scale:
0 Did not make a significant attempt
1 Make a significant attempt but got stuck early on
2 Reasonable attempt
4 Approach is mostly correct
Examinations and a class project were used to evaluate student performance.

Contribution of course to meeting the professional component:
Application of engineering science and design to achieve robust, stable controllers. Students evaluate various control objectives such as safety, productivity and profitability to practice their engineering judgment. Students also evaluate the complexity of a model for the purpose of achieving a desired goal in light of constraints imposed on the design. Students iterate on these design decisions.

Relationship of course to program outcomes: The contribution of CHE 118 to program outcomes (a)-(k) or (1) – (11) is summarized in the objective-outcome matrix table

Objective-Outcome Matrix
Objective Addresses Outcome: 1-Slightly 2-Moderately 3-Substantially

Outcome Related Learning Objectives	Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5	Outcome 6	Outcome 7	Outcome 8	Outcome 9	Outcome 10	Outcome 11
Derive appropriate differential equations to describe process dynamics from fundamental principles (e.g., mass balance, energy balance, species balance, etc)	3	0	0	0	3	0	0	1	0	1	3
Use the equations derived in #1 to formulate models of appropriate complexity and relevance for process control, stability analysis, and dynamic analyses	3	0	0	0	3	0	0	1	0	1	2
Identify the order, stability, and approximate dynamic response of a linear model based on analysis of the transfer function and/or of experimental data	3	3	0	0	3	0	0	1	0	1	2
Based on data, estimate the parameters of a model suitable for process control purposes	3	3	0	0	3	0	0	0	0	1	3
Simulate open and closed loop dynamic behavior in Simulink (e.g., construct Simulink based models, determine appropriate parameters and constraints for the simulations, and analyze the resulting behavior)	3	0	1	0	3	0	0	0	0	2	3
Design control mechanisms to stabilize unstable processes.	3	0	3	0	3	1	0	1	0	1	3
Prepare technical communications of varying complexities based on work in process dynamics and control	1	0	2	3	1	0	3	0	0	1	0
Design single input, single output control loops for common processes in order to meet a desired need.	3	0	3	0	3	0	0	1	0	1	3
Design preliminary control loops for advanced control issues (model based control, MIMO, cascade, etc)	3	0	3	0	3	0	0	1	0	1	3
Incorporate process control for safety, environmental compliance, and profit maximization	2	0	3	0	3	2	0	3	0	3	0

Prepared by and date of preparation: K. Kauffman; May 30, 2006

Department, number and title of course: Department of Chemical and Environmental Engineering CHE 120– Mass Transfer

Required/Elective course: Required Course

Catalog description: Introduction to analysis of mass transfer in systems of interest to chemical and environmental engineering practice. Transport of matter by diffusion, free and forced convection.

Prerequisite(s): CHE 114, ENGR 118, and either CHE 110A or ENVE 171; or consent of instructor.

Textbook(s) and/or other required material:
Fundamentals of Momentum, Heat, and Mass Transfer. J.R. Welty, C.E. Wicks, R.E. Wilson, Rorrer, G. (4th ed. Wiley)

Course objectives: Upon completion of this course, students should be able to:
1. Understand basic mass transfer theory
2. Understand similarity between heat, momentum and mass transfer
3. Know how to calculate diffusion coefficient in liquids or gases
4. Know how to solve steady-state and dynamic problems of diffusive mass transfer, with or without reaction.
5. Understand theory and applications of convective mass transfer
6. Understand theory and applications of interphase mass transfer
7. Practice problem solving skills (discussion)

Topics covered: Fundamentals of mass transfer, Determination of diffusion coefficient, Steady-state molecular diffusion, Continuity equation, Unsteady-state molecular diffusion, Convective mass transfer (exact solution, models), Interphase mass transfer, Convective mass transfer correlations

Class/laboratory schedule: Lecture, 3 hours; discussion, 1 hour

Assessment methods:

Final exam	50%
Midterm	30%
Assignments, discussion, quizzes	20%;

if a min of 40% (for the combined Assignments, discussion, quizzes) is not reached, the final grade for the class is automatically F

Contribution of course to meeting the professional component:
This course, taken both by chemical and environmental engineering students, is one of the three courses focusing on transport phenomena. The course covers basic principles of mass transfer by diffusion and convection and their application in chemical and environmental engineering systems. The determination of diffusion coefficients, theories and models for diffusive and convective mass transfer, with or without chemical reaction, and interphase mass transfer are presented and practiced. Laboratory exercises in mass transfer are covered in CHE/ENVE 160A.

Relationship of course to program outcomes: The contribution of CHE 120 to program outcomes (a)-(k) or (1) – (11) is summarized in the objective-outcome matrix table

Objective-Outcome Matrix
Objective Addresses Outcome: 1-Slightly 2-Moderately 3-Substantially

Outcome Related Learning Objectives	Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5	Outcome 6	Outcome 7	Outcome 8	Outcome 9	Outcome 10	Outcome 11
Understand basic mass transfer theory	3	0	0	0	0	0	0	0	0	0	1
Understand similarity between heat, momentum and mass transfer	3	0	0	0	2	0	0	1	0	0	1
Know how to calculate diffusion coefficient in liquids or gases	2	1	0	0	2	0	0	0	0	0	1
Know how to solve steady-state and dynamic problems of diffusive mass transfer, with or without reaction.	3	0	1	0	3	0	0	0	0	0	2
Understand theory and applications of convective mass transfer	3	0	1	0	3	0	0	0	0	0	2
Understand theory and applications of interphase mass transfer	3	0	1	0	3	0	0	0	0	0	2
Practice problem solving skills (discussion)	3	2	2	2	3	0	2	1	1	0	2

Prepared by and date of preparation: Dr. M. Deshusses; May 30, 2006

Department, number and title of course: Department of Chemical and Environmental Engineering CHE 122 – Chemical Engineering Kinetics

Required/Elective course: Required Course

Catalog description: Introduction to homogeneous and heterogeneous kinetics and reactor design for chemical and biochemical processes.

Prerequisite(s): CHEM 001C, MATH 010A, MATH 046, PHYS 040B; or consent of instructor.

Textbook(s) and/or other required material:
Chemical Reaction Engineering by Levenspiel, 3rd Edition, Wiley, 1999.

Course objectives: Upon completion of this course, students should be able to:

1. In one or two sentences, explain in jargon-free language: equilibrium vs. kinetics, reaction rate, fractional conversion, molar expansion factor, reaction order, elementary reaction, batch reactor, plug flow reactor (PFR), continuous stirred tank reactor (CSTR), and residence time distribution
2. Calculate equilibrium constants at different temperatures based on thermodynamic data of enthalpy and Gibbs free energy
3. Based on concentration vs. time data, determine the reaction order and reaction rate constants for an appropriate reaction rate expression
4. Be able to handle a single reaction as well as multiple reactions such as equilibrium reactions and reactions in series and in parallel
5. Set up design equations for Batch, PFR, and CSTR systems and be able to apply them for to size reactors or predict conversion
6. Understand the behaviors, benefits, and limitations of each standard reactor system
7. Be able to analyze simple reactor systems involving reactors in series, in parallel, and with recycle
8. Be able to analyze non-isothermal ideal reactors systems
9. Understand non-ideal reactors and the analysis of residence time distribution

Topics covered:

1. **Overview of Reaction Engineering, Kinetics of Homogeneous Reactions Week 1**
   Classification of reactions, definition of reaction rates
   Concentration and temperature dependence of rate equations
   Development of reaction mechanisms

2. **Interpretation of Batch Reaction Data, Introduction to Reactor Design Week 2**
   Integral and differential methods of reaction data analysis
   Constant volume and variable volume systems
   Reversible and irreversible reactions
   Use of conversion and concentration

3. **Ideal Reactors for a Single Reaction, Design for Parallel Reactions Week 3**
   Batch, steady state stirred tank, and steady state plug flow reactors
   Space time and space velocity
   Contacting patterns, product distributions, and selectivity

4. **Multiple Reactions, Temperature and Pressure Effects** **Week 4**
   Irreversible and reversible multiple reactions in series
   Multiple reactions in batch, mixed, and plug flow reactors
   Heats of reaction and equilibrium effects
   Effects of temperature and pressure on single and multiple reactions

5. **Choosing the Right Reactor,** **Week 5**
   Change in reactor choice with reaction types
   Effects of temperature on choice of reaction

6. **Basics of Non-Ideal Flow, Compartment Models, Dispersion** **Weeks 5 and 6**
   Pulse input, step input, and the residence time distribution of fluid
   Conversion in non-ideal flow reactors
   Active and dead volumes and flow patterns
   Axial dispersion, correlations, and effects on reaction

7. **Tanks-in-Series, Convection Models, Mixing and Segregation** **Weeks 7 and 8**
   Pulse response experiments and RTD for tanks in series
   The convection model for laminar flow
   Chemical conversions in laminar flow reactors
   Self mixing of a single fluid and mixing of two miscible fluids

8. **Heterogeneous Reactions, Solid Catalyzed Reactions** **Week 9**
   Overview of heterogeneous systems
   Rate equations for surface kinetics
   Film and pore diffusion effects
   Heat effects during solid catalyzed reactions

10. **The Packed Bed Catalytic Reactor, Fluidized Reactors** **Week 10**
   Staged adiabatic packed bed reactors
   Bubbling and circulating fluidized bed reactors

Class/laboratory schedule: Lecture, 3 hours; discussion, 1 hour.

Assessment methods:

Homework Assignments	30%
Exam 1	30%
Exam 2	40%

Contribution of course to meeting the professional component:
This course provides the foundation for the analysis and design of chemical reaction systems. Mathematical models are developed to describe various types of chemical reactions and how they are influenced by chemical concentrations, temperature, pressure, and other physical and chemical conditions for homogeneous systems involving both irreversible and reversible reactions. These models are then used to design batch, steady state mixed flow, and steady state plug flow reactors. In addition, mathematical models are developed to account for non-ideal flows and applied to determine the influence of non-ideal flow on the design of reactors for various classes of reactions. Heterogeneous reactors are also analyzed including predicting how film and pore mass transfer and

heat transfer impact reactor performance and design. These tools are then applied to describe packed and fluidized bed reactors.

Relationship of course to program outcomes: The contribution of CHE 122 to program outcomes (a)-(k) or (1) – (11) is summarized in the objective-outcome matrix table

Objective-Outcome Matrix
Objective Addresses Outcome: 1-Slightly 2-Moderately 3-Substantially

Outcome Related Learning Objectives	Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5	Outcome 6	Outcome 7	Outcome 8	Outcome 9	Outcome 10	Outcome 11
In one or two sentences, explain in jargon-free language: *equilibrium vs. kinetics, reaction rate, fractional conversion, molar expansion factor, reaction order, elementary reaction, batch reactor, plug flow reactor (PFR), continuous stirred tank reactor (CSTR), and residence time distribution*							3				
Calculate equilibrium constants at different temperatures based on thermodynamic data of enthalpy and Gibbs free energy	3	1			3						2
Based on concentration vs. time data, determine the reaction order and reaction rate constants for an appropriate reaction rate expression	3	2			3						
Be able to handle a single reaction as well as multiple reactions such as equilibrium reactions and reactions in series and in parallel	3	2	1		2						2
Set up design equations for Batch, PFR, and CSTR systems and be able to apply them for to size reactors or predict conversion	3	2	3		3						
Understand the behaviors, benefits, and limitations of each standard reactor system	3		2		2						
Be able to analyze simple reactor systems involving reactors in series, in parallel, and with recycle	3	1	3		3						
Be able to analyze non-isothermal ideal reactors systems	3	1	1		3	3					1
Understand non-ideal reactors and the analysis of residence time distribution	3	1	1		2				3		1

Prepared by and date of preparation: C. Wyman; May 31, 2006

Department, number and title of course: Department of Chemical and Environmental Engineering CHE 124– Biochemical Engineering Principles

Required/Elective course: Required Course for the Biochemical Engineering option, Technical Elective for the Bioengineering option

Catalog description: Examines the principles of biochemical engineering. Topics include kinetics of enzymatic reactions and microbial growth, batch and continuous culture reactors, product formulation, and nutrient utilization. Also studies oxygen transfer, bioreactor scale-up, air and media sterilization, fundamentals of bioreactor design, and bioseparations.

Prerequisite(s): BCH 110A, BIOL 121/MCBL 121 (BIOL 121/MCBL 121 may be taken concurrently), CHE 120, CHE 122; or consent of instructor.

Textbook(s) and/or other required material: Biochemical Engineering by J.M. Lee

Course objectives:

1. Knowledge of basics of biology, workings of cells and metabolic pathways and identify microorganisms and enzymes used in bioprocessing technologies
2. An ability to choose and apply simple models of enzyme kinetics, formulate kinetic models based on given reaction sequence and determine kinetic parameters
3. An ability to set-up design equations and apply them for batch and continuous enzyme reactors design - sizing or conversion
4. An ability to apply simple models of cell growth kinetics and determine kinetic parameters
5. An ability to set-up design equations and apply them for batch, chemostat, fed-batch and recycle microbial bioreactors design - sizing or conversion
6. An ability to apply chemical engineering principles of momentum, mass and heat transfers, kinetics and thermodynamics in the design and scale-up of bioreactors and design sterilizers
7. An ability to research the literature for a given topic in the area of biotechnology and report in oral and written form

Topics covered: Kinetics of enzyme reactions, Application of enzyme kinetics to design batch and continuous enzyme reactors, Kinetics of immobilized enzymes, Microbial growth, substrate consumption and product formation kinetics, Application of microbial kinetics to design batch and continuous bioreactors, Design and scale-up of stirred tank reactors and Design of liquid and air sterilizers. Laboratory exercises in biochemical engineering are covered in CHE 124L.

Class/laboratory schedule: Lecture, 3 hours; discussion, 1 hour.

Assessment methods:

Homework, quizzes, report and class participation	20%
Midterms (2)	30%
Final	40%

Grading Scheme: 90+ A+, 85-89 A; 80-84 A-, 75-79 B+, 70-74 B, 65-69, B-, 60-64 C+, 55-59 C, 50-54 C-, 45-49 D+, 40-44 D

Contribution of course to meeting the professional component: The course contributes to the engineering science and engineering design components of the Chemical Engineering and Environmental Engineering curriculum. Students learn of enzyme and microbial kinetics and apply the knowledge to design of batch and continuous enzyme and microbial reactors. Additionally, the course integrates the concepts of momentum, mass and heat transfer into design and scale-up of stirred tank bioreactors and design of liquid and air sterilizers. Homework, classroom sample problems, and exams challenge students in their problem solving skills.

Relationship of course to program outcomes: The contribution of CHE 124 to program outcomes (a)-(k) or (1) – (11) is summarized in the objective-outcome matrix table

Objective-Outcome Matrix

Objective Addresses Outcome: 1-Slightly 2-Moderately 3-Substantially

Outcome Related Learning Objectives	**Outcome 1**	**Outcome 2**	**Outcome 3**	**Outcome 4**	**Outcome 5**	**Outcome 6**	**Outcome 7**	**Outcome 8**	**Outcome 9**	**Outcome 10**
Knowledge of basics of biology, workings of cells and metabolic pathways and identify microorganisms and enzymes used in bioprocessing technologies	2			2			2		1	
An ability to choose and apply simple models of enzyme kinetics, formulate kinetic models based on given reaction sequence and determine kinetic parameters	3	2			3					
An ability to set-up design equations and apply them for batch and continuous enzyme reactors design - sizing or conversion	3		3		3					
An ability to apply simple models of cell growth kinetics and determine kinetic parameters	3	2			3					
An ability to set-up design equations and apply them for batch, chemostat, fed-batch and recycle microbial bioreactors design - sizing or conversion	3		3		3					
An ability to apply chemical engineering principles of momentum, mass and heat transfers, kinetics and thermodynamics in the design and scale-up of bioreactors and design sterilizers	3	2	3		3					
An ability to research the literature for a given topic in the area of biotechnology and report in oral and written form	1			2			3		1	2

Prepared by and date of preparation: A. Mulchandani; May 31, 2006

Department, number and title of course: Department of Chemical and Environmental Engineering, CHE 124L– Biochemical Engineering Laboratory

Required/Elective course: Required Course for the Biochemical Engineering option

Catalog description: Laboratory practices in biochemical engineering. Determination of microbial kinetics and biologically mediated reactions, oxygen transfer coefficients. Batch and continuous culturing, air and media sterilization, bioseparations.

Prerequisite(s): CHE 124 or consent of instructor.

Textbook(s) and/or other required material:
Lab Manual

Course objectives: Upon completion of this course, students should be able to:
1. Design and conduct experiments and analyze and interpret experimental data for the determination of kinetic parameters of enzyme catalyzed reactions without and with inhibition
2. Design and conduct experimentsand analyze data for enumerating cell growth
3. Design and conduct experiments and analyze and interpret experimental data for the determination of kinetic parameters of cell growth, substrate consumption and product formation kinetics
4. Design and conduct experiments and analyze and interpret experimental data for expression, isolation and purification of a protein from genetically engineered microorganism
5. To write technical reports in format of publication papers in journals

Topics covered: Determination of kinetic parameters for without and with inhibition, Determination of kinetics parameters for cell growth, substrate consumption and product formation kinetics for microbial fermentation, Determination of mass transfer coefficient for oxygen transfer in a stirred tank bioreactor, Protein isolation and purification

Class/laboratory schedule: Laboratory, 6 hours.

Assessment methods:

Designing and performing experiments and collecting data: 50%
Data analysis and reporting: 50%

Contribution of course to meeting the professional component: This course is a follow-up to the CHE 124, Introduction to Biochemical Engineering. It introduces students to concepts essential for making measurements relevant to Biochemical Engineering. The main objective of this course is to apply the fundamental concepts learnt in the areas of enzyme kinetics, microbial kinetics, oxygen transfer and protein purification to set up simple laboratory experiments and verify the theories formulated in CHE 124. The experiments give students an opportunity to think creatively, apply the skills developed in the course, communicate effectively through written reports and work in team.

Relationship of course to program outcomes: The contribution of CHE 124L to program outcomes (a)-(k) or (1) – (11) is summarized in the objective-outcome matrix table

Objective-Outcome Matrix

Objective Addresses Outcome: 1-Slightly 2-Moderately 3-Substantially

Outcome Related Learning Objectives	**Outcome 1**	**Outcome 2**	**Outcome 3**	**Outcome 4**	**Outcome 5**	**Outcome 6**	**Outcome 7**	**Outcome 8**	**Outcome 9**	**Outcome 10**
Design and conduct experiments and analyze and interpret experimental data for the determination of kinetic parameters of enzyme catalyzed reactions without and with inhibition	3	3		2						
Design and conduct experiments and analyze data for enumerating cell growth	3	3		2						
Design and conduct experiments and analyze and interpret experimental data for the determination of kinetic parameters of cell growth, substrate consumption and product formation kinetics	3	3		2						
Design and conduct experiments and analyze and interpret experimental data for expression, isolation and purification of a protein from genetically engineered microorganism	3	3		2						
To write technical reports in format of publication papers in journals	3	3		2			3			1

Prepared by and date of preparation: A. Mulchandani; May 31, 2006

Department, number and title of course: Department of Chemical and Environmental Engineering CHE/ENVE 130– Advanced Engineering Thermodynamics

Required/Elective course: Required Course

Catalog description: Advanced study of chemical thermodynamics and their applications to chemical and environmental engineering processes. Principles for the thermodynamic behavior of pure solutions and mixtures, phases, and chemical equilibria for homogeneous and heterogeneous systems are applied to a variety of processes common to chemical and environmental engineering.

Prerequisite(s): CHE 100, MATH 010B (MATH 010B may be taken concurrently); or consent of instructor.

Textbook(s) and/or other required material:
Introduction to Chemical Engineering Thermodynamics by Smith, Van Ness and Abbott (2004). McGraw-Hill. (7th ed.).

Recommended Supplemental Texts:
Fundamentals of Engineering Thermodynamics by Moran and Shapiro, 4th ed. (Wiley, 2000)
Chemical and Engineering Thermodynamics by Sandler, 3rd ed. (Wiley, 1999).
Introductory Chemical Engineering Thermodynamics by Elliot and Lira (Prentice Hall 1999).

Course objectives: Upon completion of this course, students should be able to:
1. Understand basic introductory concept
2. Understand ideal vapor-liquid equilibrium and fugacities of vapor and liquid
3. Understand and apply thermodynamics of mixing and partial molar properties and auxiliary functions for phase and chemical equilibria
4. Understand excess Gibbs energy models: experimental data are the best!
5. be able to solve examples of phase equilibrium and partial miscibility
6. Understand "ideal solubility and enhancement factor"
7. Understand freezing point depression and osmotic equilibrium
8. Understand chemical equilibrium for single chemical reaction
9. Understand and apply Gibbs phase rule
10. Understand and apply multireaction equilibrium and combined chemical and phase equilibrium

Topics covered:
1. Ideal vapor-liquid equilibrium
2. Fugacities of vapor and liquid
3. Thermodynamics of mixing and partial molar properties and auxiliary functions for phase and chemical equilibria
4. Excess Gibbs energy models
5. Examples of phase equilibrium and partial miscibility
6. Ideal solubility and enhancement factor
7. Solution thermodynamics
8. Freezing point depression
9. Osmotic equilibrium
10. Chemical equilibrium for single chemical reaction
11. Gibbs phase rule
12. Multireaction equilibrium and combined chemical and phase equilibrium

Class/laboratory schedule: Lecture, 3 hours; discussion, 1 hour.

Assessment methods:

Class attendance:	10	A: >80 (or final >85)
Homework:	15	B: >70
In-class quizzes:	3×5	C: >60
Midterm Exams:	25	D: >50
Final Exam:	35	F: <45

Contribution of course to meeting the professional component:
This course will help students understand the fundamentals of chemical and environmental engineering, in particular, knowledge related to solution thermodynamics, equilibrium, separation, and reaction engineering. In addition, it will benefit students to develop life-time learning skills, problem solving, team work, and technical communications.

Relationship of course to program outcomes: The contribution of CHE/ENVE 130 to program outcomes (a)-(k) or (1) – (11) is summarized in the objective-outcome matrix table

Objective-Outcome Matrix
Objective Addresses Outcome: 1-Slightly 2-Moderately 3-Substantially

Outcome Related Learning Objectives	Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5	Outcome 6	Outcome 7	Outcome 8	Outcome 9	Outcome 10	Outcome 11
Understand basic introductory concept	2		3				1	2			1
Understand ideal vapor-liquid equilibrium and fugacities of vapor and liquid	3				2		1				1
Understand and apply thermodynamics of mixing and partial molar properties and auxiliary functions for phase and chemical equilibria	3				2		1				1
Understand excess Gibbs energy models: experimental data are the best!	3	2			2		1				1
be able to solve examples of phase equilibrium and partial miscibility	3				2		1				1
Understand "ideal solubility and enhancement factor"	3				2		1				1
Understand freezing point depression and osmotic equilibrium	3				2		1				1
Understand chemical equilibrium for single chemical reaction	3				2		1				1
Understand and apply Gibbs phase rule	3				2		1				1
Understand and apply multireaction equilibrium and combined chemical and phase equilibrium	3				2		1				1

Prepared by and date of preparation: J. Wu; May 31, 2006

Department, number and title of course: Department of Chemical and Environmental Engineering CHE 160A/ENVE 160A– Chemical and Environmental Engineering Laboratory

Required/Elective course: Required Course

Catalog description: Involves laboratory exercises in chemical and environmental engineering. Experiments cover physical measurements, fluid mechanics, and mass transfer. Emphasizes experimental design, analysis of results, and preparation of engineering reports.

Prerequisite(s): CHE 114, CHE 120.

Textbook(s) and/or other required material:
Chemical Engineering Laboratory I Lab Manual
Environmental Engineering Laboratory I Lab Manual

Course objectives:
1. Ability to organize pre-lab write-ups prior to experimentation and review phenomena
2. Understanding and determination of experimental errors
3. Determine and explain phenomena from experimental data
4. Ability to summarize data analysis and present in concise format and make recommendations to experimental procedures
5. To write technical reports in format of publication papers in journals
6. Effective oral presentation of experiments conducted and discussion of results
7. Relating phenomena studied in course to industrial processes and orally presenting processes researched.
8. Ability to conduct laboratory experiments efficiently within time limit.
9. Ability to utilize modeling software to predict process control outcomes.

Topics covered:
1. Pipe friction and fitting (headloss)
2. Gas diffusion
3. Liquid diffusion
4. Pump characteristics
5. Wetted wall column
6. K_La determination

Class/laboratory schedule: Laboratory, 6 hours; written work, 3 hours.

Assessment methods:
50 % Lab Report
30 % Presentation
10 % Lab Notebook
10 % Attendance

Contribution of course to meeting the professional component:
This course introduces students to concepts essential for making measurements relevant to Chemical and Environmental Engineering, including selection and application of sensor/transducer systems, and data analysis. It enables students to design and conduct reliable experimental measurements. Laboratory work includes writing of technical memoranda and reports and make oral presentations.

The main objective of this course is to apply the fundamental concepts learned in fluid mechanics and mass transfer to set up simple laboratory experiments and verify the theories formulated in the various courses. The experiments give students an opportunity to think creatively, apply the skills developed in the course and communicate effectively through written reports and oral presentations.

Relationship of course to program outcomes: The contribution of CHE/ENVE 160A to program outcomes (a)-(k) or (1) – (11) is summarized in the objective-outcome matrix table

Objective-Outcome Matrix

Objective Addresses Outcome: 1-Slightly 2-Moderately 3-Substantially

Outcome Related Learning Objectives	Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5	Outcome 6	Outcome 7	Outcome 8	Outcome 9	Outcome 10	Outcome 11
Ability to organize pre-lab write-ups prior to experimentation and review phenomena	1	0	1	3	1	0	1	0	0	0	1
Understanding and determination of experimental errors	3	2	3	0	2	0	0	0	0	0	2
Determine and explain phenomena from experimental data	3	2	0	3	3	0	3	0	0	0	3
Ability to summarize data analysis and present in concise format and make recommendations to experimental procedures	2	2	2	3	3	0	3	0	0	0	2
To write technical reports in format of publication papers in journals	0	0	0	3	0	0	3	2	0	2	2
Effective oral presentation of experiments conducted and discussion of results	0	0	0	2	0	0	3	0	0	0	3
Relating phenomena studied in course to industrial processes and orally presenting processes researched.	0	0	0	0	0	1	3	3	0	3	2
Ability to conduct laboratory experiments efficiently within time limit.	1	3	2	3	1	0	2	0	0	0	2
Ability to utilize modeling software to predict process control outcomes.	2	0	1	3	2	0	0	0	0	0	0

Prepared by and date of preparation: N. Myung; May 31, 2006

Department, number and title of course: Department of Chemical and Environmental Engineering CHE 160B- Chemical Engineering Laboratory

Required/Elective course: Required Course

Catalog description: Consists of laboratory exercises in chemical engineering. Includes experiments in physical measurements, heat transfer, reactor analysis, and chemical kinetics. Emphasis is on experimental design, analysis of results, and preparation of engineering reports.

Prerequisite(s): CHE 116, CHE 122

Textbook(s) and/or other required material:
Chemical Engineering Laboratory I Lab Manual
Environmental Engineering Laboratory I Lab Manual

Course objectives:
1. Ability to organize pre-lab write-ups prior to experimentation and review phenomena
2. Understanding and determination of experimental errors
3. Determine and explain phenomena from experimental data
4. Ability to summarize data analysis and present in concise format and make recommendations to experimental procedures
5. To write technical reports in format of publication papers in journals
6. Effective oral presentation of experiments conducted and discussion of results
7. Relating phenomena studied in course to industrial processes and orally presenting processes researched.
8. Ability to conduct laboratory experiments efficiently within time limit

Topics covered:
Students work in teams, usually two students per team. Students alternate as Team Leader. The Team Leader is responsible for preparing the protocols before the start of the laboratory session.

Each Student is individually responsible for writing three complete reports.

Experiments:

1. Mixed-Flow Reactors in Series
2. Reaction Kinetics in a Plug-Flow Reactor
3. Linear and Radial Heat Conduction
4. Forced Convection in a Finned Heat Exchanger
5. Concentric Tube Heat Exchanger
6. Thermal Radiation

Presentations: Each Student will make two presentations

A. Each student is provided with an engineering design problem and its solution. The students then prepare an oral presentation that covers the following aspects:
a. Statement of the problem
b. Relationship of the problem to the laboratory experiments
c. Relationship of the problem to industrial practice

d. Solution of the design problem and the primary theoretical concepts involved

B. Each student will make a presentation describing one of the laboratory experiments.

Class/laboratory schedule: Laboratory, 6 hours; written work, 3 hours.

Assessment methods:
80 % Lab Reports
20 % Presentation

Contribution of course to meeting the professional component:

This course introduces students to concepts essential for making measurements relevant to Chemical Engineering, including selection and application of sensor/transducer systems, and data analysis. It enables students to design and conduct reliable experimental measurements. Laboratory work includes writing of technical memoranda and reports.
The main objective of this course is to apply the fundamental concepts learned in heat transfer and thermodynamics to set up simple laboratory experiments and verify the theories formulated in the various courses. The experiments give students an opportunity to think creatively, apply the skills developed in the course and communicate effectively through written reports.

Relationship of course to program outcomes: The contribution of CHE 160B to program outcomes (a)-(k) or (1) – (11) is summarized in the objective-outcome matrix table

Objective-Outcome Matrix
Objective Addresses Outcome: 1-Slightly 2-Moderately 3-Substantially

Outcome Related Learning Objectives	Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5	Outcome 6	Outcome 7	Outcome 8	Outcome 9	Outcome 10	Outcome 11
Ability to organize pre-lab write-ups prior to experimentation and review phenomena	1	0	1	3	1	0	1	0	0	0	1
Understanding and determination of experimental errors	3	2	3	0	2	0	0	0	0	0	2
Determine and explain phenomena from experimental data	3	2	0	3	3	0	3	0	0	0	3
Ability to summarize data analysis and present in concise format and make recommendations to experimental procedures	2	2	2	3	3	0	3	0	0	0	2
To write technical reports in format of publication papers in journals	0	0	0	3	0	0	3	2	0	2	2
Effective oral presentation of experiments conducted and discussion of results	0	0	0	2	0	0	3	0	0	0	3
Relating phenomena studied in course to industrial processes and orally presenting processes researched.	0	0	0	0	0	1	3	3	0	3	2
Ability to conduct laboratory experiments efficiently within time limit.	1	3	2	3	1	0	2	0	0	0	2

Prepared by and date of preparation: J. Schultz; May 31, 2006

Department, number and title of course: Department of Chemical and Environmental Engineering CHE 160C- Chemical Engineering Laboratory

Required/Elective course: Required Course

Catalog description: Consists of laboratory exercises in chemical engineering. Includes experiments and simulations in separation processes and in process control. Emphasis is on experimental design, analysis of results, and preparation of engineering reports.

Prerequisite(s): CHE 117, CHE 118 (CHE 118 may be taken concurrently), CHE 122.

Textbook(s) and/or other required material:
Chemical Engineering Laboratory I Lab Manual
Environmental Engineering Laboratory I Lab Manual

Course objectives:
1. Ability to organize pre-lab write-ups prior to experimentation and review phenomena
2. Understanding and determination of experimental errors
3. Determine and explain phenomena from experimental data
4. Ability to summarize data analysis and present in concise format and make recommendations to experimental procedures
5. To write technical reports in format of publication papers in journals
6. Effective oral presentation of experiments conducted and discussion of results
7. Relating phenomena studied in course to industrial processes and orally presenting processes researched.
8. Ability to conduct laboratory experiments efficiently within time limit.
9. Ability to utilize modeling software to predict process control outcomes.

Topics Covered:
Students work in teams, usually two students per team. Students alternate as Team Leader. The Team Leader is responsible for preparing the protocols before the start of the laboratory session. Each Student is individually responsible for writing three complete reports.

Experiments:
1. Tray Drier
2. Distillation Column
3. Liquid-liquid Extraction
4. Gas Absorption
5. Liquid Level Control/LabView

Presentations: Each Student will make two presentations
A. Each student is provided with an engineering design problem and its solution. The students then prepare an oral presentation that covers the following aspects:
  a. Statement of the problem
  b. Relationship of the problem to the laboratory experiments
  c. Relationship of the problem to industrial practice
  d. Solution of the design problem and the primary theoretical concepts involved
B. Each student will make a presentation describing one of the laboratory experiments

Class/laboratory schedule: Laboratory, 6 hours; written work, 3 hours.
Assessment methods:
80 % Lab Reports
20 % Presentation

Contribution of course to meeting the professional component:
This course introduces students to concepts essential for making measurements relevant to Chemical Engineering, including selection and application of sensor/transducer systems, and data analysis. It enables students to design and conduct reliable experimental measurements. Laboratory work includes writing of technical memoranda and reports.
The main objective of this course is to apply the fundamental concepts learnt in separations, reactor dynamics, and control to set up simple laboratory experiments and verify the theories formulated in the various courses. The experiments give students an opportunity to think creatively, apply the skills developed in the course and communicate effectively through written reports.

Relationship of course to program outcomes: The contribution of CHE 160C to program outcomes (a)-(k) or (1) – (11) is summarized in the objective-outcome matrix table

Objective-Outcome Matrix
Objective Addresses Outcome: 1-Slightly 2-Moderately 3-Substantially

Outcome Related Learning Objectives	Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5	Outcome 6	Outcome 7	Outcome 8	Outcome 9	Outcome 10	Outcome 11
Ability to organize pre-lab write-ups prior to experimentation and review phenomena	1	0	1	3	1	0	1	0	0	0	1
Understanding and determination of experimental errors	3	2	3	0	2	0	0	0	0	0	2
Determine and explain phenomena from experimental data	3	2	0	3	3	0	3	0	0	0	3
Ability to summarize data analysis and present in concise format and make recommendations to experimental procedures	2	2	2	3	3	0	3	0	0	0	2
To write technical reports in format of publication papers in journals	0	0	0	3	0	0	3	2	0	2	2
Effective oral presentation of experiments conducted and discussion of results	0	0	0	2	0	0	3	0	0	0	3
Relating phenomena studied in course to industrial processes and orally presenting processes researched.	0	0	0	0	0	1	3	3	0	3	2
Ability to conduct laboratory experiments efficiently within time limit.	1	3	2	3	1	0	2	0	0	0	2
Ability to utilize modeling software to predict process control outcomes.	2	0	1	3	2	0	0	0	0	0	0

Prepared by and date of preparation: J. Schultz; May 31, 2006

Department, number and title of course: Department of Chemical and Environmental Engineering CHE/ENVE 175A- Senior Design Project

Required/Elective course: Required Course

Catalog description: Under the direction of a faculty member, students (individually or in small teams with shared responsibilities) propose, design, build, and test environmental engineering devices or systems. A written report, giving details of the project and test results, and an oral presentation of the design aspects are required. Graded In Progress (IP) until ENVE 175A and ENVE 175B are completed, at which time a final, letter grade is assigned.

Prerequisite(s): Senior standing in Chemical/Environmental Engineering.

Textbook(s) and/or other required material:
Plant Design and Economics for Chemical Engineers by Peters, Timmerhaus and West, 5th ed., , McGraw-Hill, New York, 2003.

Course objectives:
1. Ability to write a project proposal with estimated budget and Gantt chart in teams
2. Ability to produce memos and timesheets similar to a consultation practice in groups
3. Research design topic, determine and critically analyze design parameters and their effects in teams
4. Research alternative processes and having ability to determine best solution based on design, safety and economics in teams
5. Understanding and using the methods of project evaluation for comparing alternative projects.
6. Ability to formulate block and process flow diagrams and perform associated mass and energy balances in teams
7. To generate computer simulations to model processes (SuperPro, PROII)
8. To examine and identify all waste streams generated in design process and select appropriate treatment solutions in teams
9. To understand concepts of engineering economy including cost estimation
10. Effectively present oral updates, and end-of-quarter progress of design project.

Topics covered: Conceptual design of systems including process development and flowsheeting, general design considerations including health and safety and hazards analysis of processes including treatment systems, selection of appropriate pollution abatement systems, green engineering and sustainability concepts, optimization of systems including heat exchanger integration (pinch technology), and cost estimation methodologies for process systems. Other topics covered include project management, intercultural team dynamics and effective brainstorming and application of industrial simulation software packages including SuperPro, and PROII.

Class/laboratory schedule: Laboratory, 6 hours; consultation, 1 hour; lecture, 1 hour

Assessment methods:

Homework Assignments / Tutorials:	15 %
Final Exam (W05) / Final Exams (S05) (20/20):	40 %
Winter Quarter Report / Oral:	5 %
Design Notebook:	5 %
Final Report:	20 %

Final Oral Presentation:	10 %
Other Deliverables* & presentation participation:	5 %

* Oral presentation updates, memos and time sheets

Contribution of course to meeting the professional component:
This course is taught over a two-quarter series as CHE/ENVE 175A and CHE/ENVE 175B. Knowledge is acquired through lectures and a major design project, with reasonable boundary constraints, performed in teams of three or four students. The design project requires students to address a global view of many considerations in design including conceptualization, process development, health and safety, process optimization including heat integration, societal and environmental impacts with sustainability issues and economics of the designed system. In CHE/ENVE 175A, students present Gantt charts outlining the various stages of background research, problem definition, generation and evaluation of design concepts for comparison of possible alternatives, with the realization that these steps may be iterative. In addition to developing competency in design using knowledge in math, sciences, and engineering through homework assignments and in their design calculations, the course is structured to emphasize project management skills, including leadership abilities where the role of project leader is on a rotation basis every 2 weeks, allowing every student to experience the task of leading a team, managing team dynamics, organizing tasks, and providing 10 to 15-min oral updates (similar to a consultation practice) and memos featuring their accomplishments and subsequent plans. Students are required to maintain a log or design notebook that will illustrate the evolution of the design. Students recognize the need for knowledge of the latest technologies or implementations pertaining to their design strategies; for example, a team working on arsenic removal from the Los Angeles (LA) aqueduct is in contact with the on-site LA aqueduct designers to address issues that are faced in the real world. The students then develop design strategies that would allay these issues. Dependent on the project, students may have the opportunity to develop experimental designs to conduct laboratory experiments, analyze lab results and implement the results in a large scale design. The end of the first quarter culminates in progress reports provided in the form of an end-of-quarter report and an oral presentation.

Relationship of course to program outcomes: The contribution of CHE/ENVE 175A to program outcomes (a)-(k) or (1) – (11) is summarized in the objective-outcome matrix table

Objective-Outcome Matrix

Objective Addresses Outcome: 1-Slightly 2-Moderately 3-Substantially

Outcome Related Learning Objectives	**Outcome 1**	**Outcome 2**	**Outcome 3**	**Outcome 4**	**Outcome 5**	**Outcome 6**	**Outcome 7**	**Outcome 8**	**Outcome 9**	**Outcome 10**	**Outcome 11**
Ability to write a project proposal with estimated budget and Gantt chart in teams			2	3		2	2	2	1		2
Ability to produce memos and timesheets similar to a consultation practice in groups				3		2	2	1			2
Research design topic, determine and critically analyze design parameters and their effects in teams	2		2	3	2			2	2	2	2
Research alternative processes and having ability to determine best solution based on design, safety and economics in teams	3		3	3	3	2		2	1	2	2
Understanding and using the methods of project evaluation for comparing alternative projects.	3	2			2						2
Ability to formulate block and process flow diagrams and perform associated mass and energy balances in teams	3	2	2	2	3						1
To generate computer simulations to model processes (SuperPro, PROII)	1	2	2								1
To examine and identify all waste streams generated in design process and select appropriate treatment solutions in teams	2		2	2	1	2		2		2	1
To understand concepts of engineering economy including cost estimation	3				2						1
Effectively present oral updates, and end-of-quarter progress of design project.				3		1	3				2

Prepared by and date of preparation: K. Tam; May 31, 2006

Department, number and title of course: Department of Chemical and Environmental Engineering CHE/ENVE 175B- Senior Design Project

Required/Elective course: Required Course

Catalog description: Under the direction of a faculty member, students (individually or in small teams with shared responsibilities) propose, design, build, and test environmental engineering devices or systems. A written report, giving details of the project and test results, and an oral presentation of the design aspects are required. Satisfactory (S) or No Credit (NC) grading is not available.

Prerequisite(s): Senior standing in Chemical/Environmental Engineering; CHE 175A/ENVE 175A.

Textbook(s) and/or other required material:
Plant Design and Economics for Chemical Engineers by Peters, Timmerhaus and West, 5th ed., , McGraw-Hill, New York, 2003.

Course objectives:
1. Ability to create an organized design notebook featuring evolution of design work and calculations, and write a final design report in teams
2. Ability to produce memos and timesheets similar to a consultation practice in groups
3. Research design topic, determine and critically analyze design parameters and their societal and environmental impacts including sustainability issues in teams
4. Research alternative processes and having ability to determine a best solution based on design, safety, and economics in teams
5. Understanding and using the methods of project evaluation or profitability for comparing alternative projects
6. Ability to formulate block and process flow diagrams and perform associated mass and energy balances in teams
7. To generate computer simulations to model processes (SuperPro, PROII)
8. To examine and identify all waste streams generated in design project process and select appropriate treatment solutions in teams
9. To understand concepts of engineering economy including cost estimation, time value of money, taxes, depreciation and profitability analysis
10. Effectively present oral updates, and final oral presentation of the design project in teams.

Topics covered:
Engineering economy concepts including nominal and effective interest rates, time value of money, taxes, depreciation and insurance. Profitability analyses including payback period, return on investment, discounted payback period, net present value, rate of return, equivalent annual worth, benefit-cost ratio, and incremental analyses. Other topics covered include materials selection/ corrosion, and an ethics review. Further instruction in simulation software packages including the steady-state simulators of SuperPro, and PROII, and transient simulations modeling process startup, and upsets using DYNSIM.

Class/laboratory schedule: Laboratory, 6 hours; consultation, 1 hour; lecture, 1 hour.

Assessment methods:
Homework Assignments / Tutorials: 15 %
Final Exam (W05) / Final Exams (S05) (20/20): 40 %

Winter Quarter Report / Oral:	5 %
Design Notebook:	5 %
Final Report:	20 %
Final Oral Presentation:	10 %
Other Deliverables* & presentation participation:	5 %

* Oral presentation updates, memos and time sheets

Contribution of course to meeting the professional component:
This course is taught over a two-quarter series as CHE/ENVE 175A and CHE/ENVE 175B. Knowledge is acquired through lectures and a major design project, with reasonable boundary constraints, performed in teams of three or four students. The design project requires students to address a global view of many considerations in design including conceptualization, process development, health and safety, process optimization including heat integration, societal and environmental impacts with sustainability issues and economics of the designed system. In CHE/ENVE 175B, students experience the iterative nature of the design process with continuing stages of background research, problem definition, generation and evaluation of design concepts for comparison of possible alternatives. Students continue to use their knowledge in math, sciences, and engineering through homework assignments and in their design calculations. Simulation softwares are used to model their design processes for ease of optimization. Project management skills are further honed with the project leader role continuing to rotate on a bimonthly basis amongst the team members. Students continue to provide bimonthly 10 to 15-min oral updates (similar to a consultation practice) and memos featuring their accomplishments and subsequent plans. The end of the second quarter culminates in three design project deliverables including a completed design notebook showing the evolution of their design process, a final report showcasing the background to the project, the problem definition, process flow diagrams and designs, comparisons of the design alternatives including a thorough discussion of the profitability, the social (including ethics) and environmental impacts (including sustainability), health and safety of the designs, and finally a 30 to 40-min oral presentation to an audience comprised of faculty and other guests.

Relationship of course to program outcomes: The contribution of CHE/ENVE 175B to program outcomes (a)-(k) or (1) – (11) is summarized in the objective-outcome matrix table

Objective-Outcome Matrix
Objective Addresses Outcome: 1-Slightly 2-Moderately 3-Substantially

Outcome Related Learning Objectives	Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5	Outcome 6	Outcome 7	Outcome 8	Outcome 9	Outcome 10	Outcome 11
Ability to create an organized design notebook featuring evolution of design work and calculations, and write a final design report in teams			2	3		2	2	2	1		2
Ability to produce memos and timesheets similar to a consultation practice in groups				3		2	2	1			2
Research design topic, determine and critically analyze design parameters and their effects in teams	2		2	3	2			2	2	2	2
Research alternative processes and having ability to determine best solution based on design, safety and economics in teams	3		3	3	3	2		2	1	2	2
Understanding and using the methods of project evaluation or profitability for comparing alternative projects.	3	2			2						2
Ability to formulate block and process flow diagrams and perform associated mass and energy balances in teams	3	2	2	2	3						1
To generate computer simulations to model processes (SuperPro, PROII, DYNSIM)	2	2	3	2	1				2	1	2
To examine and identify all waste streams generated in design project process and select appropriate treatment solutions in teams	2		2	2	1	2		2		2	1
To understand concepts of engineering economy including cost estimation, time value of money, taxes, depreciation and profitability analysis	3				2						1
Effectively present oral updates, and final oral presentation of the design project in teams.				3		1	3				2

Prepared by and date of preparation: K. Tam; May 31, 2006

Department, number and title of course: Department of Chemical and Environmental Engineering ENVE 120- Unit Operations and Processes in Environmental Engineering

Required/Elective course: Technical Elective for the Chemical Engineering option

Catalog description: Fundamentals of physicochemical unit processes used in environmental engineering. Coagulation and flocculation, sedimentation, filtration, adsorption, redox processes, and heat and mass transfer processes.

Prerequisite(s): ENVE 133, ENVE 142; or consent of instructor.

Textbook(s) and/or other required material:
Unit Operations and Processes in Environmental Engineering by. Reynolds and Richards, 2nd edition, PWS Publishing Company, Boston, 1996.

Course objectives: Upon completion of this course, students should be able to:
1. Demonstrate knowledge regarding primary and secondary drinking water standards; identify (using appropriate regulations) required levels of water treatment based on health risk and drinking standards
2. Effectively design a batch/PFR/CSTR reactor to achieve desired water quality results (chemical conversion, level of aeration, etc.)
3. Effectively describe the physical and chemical processes involved in water treatment via coagulation, flocculation, sedimentation, filtration and disinfection
4. Design flow equalization basins for variable water and wastewater flow conditions
5. Utilize mass transfer principles for gas/liquid separation and design air stripping and aeration systems (including chlorination)
6. Design coagulation and flocculation unit operations and sedimentation basins for water/wastewater treatment systems
7. Design a granular-medium filtration system used for water and wastewater treatment
8. Demonstrate an understanding of the design and operation theory for lime-soda ash water softening
9. Design a treatment process, integrating a number of unit operations, for the treatment of team-selected water/wastewater system. Provide cost analysis, design parameters, etc. Written and oral reports

Topics covered:
Batch, CSTR, and plug flow reactor systems, regulatory standards for water quality, overview of physical versus conversion processes, unit operations including flow equalization, screening, gas transfer (including aeration and stripping), mixing, flocculation, coagulation, sedimentation, filtration, precipitation, softening, disinfection and adsorption processes if time permits.

Class/laboratory schedule: Lecture, 3 hours; discussion, 1 hour.

Assessment methods:

Homework Assignments	20 %
Midterm	20 %
Two Quizzes	15%
Design Project	15 %
Final Exam	30%

Contribution of course to meeting the professional component:
The course focuses on a number of unit operations pertinent to the treatment of wastewater and drinking water. Math, science and engineering knowledge gained throughout the course and in previous courses are applied to a design project defined by the students. Teams of two must select and characterize waste streams that may exist in the real world and design treatment systems to meet the desired needs of appropriate environmental discharge or drinking water standards. For example, one team designed a bioremediation process that would treat the waste streams resulting from the flooding of a refinery due to the effects of Hurricane Katrina. Their results highlighted the enormity of the problem, the professional and ethical responsibilities of the real-world solution and the necessity of pumping contaminated water into Lake Pontchartrain. This design project also integrates the need for effective communication skills, working in teams, and knowledge of contemporary issues. In studying the regulatory standards for water quality, students become aware that standards may change as better treatment technologies become available and must be current on regulatory information (example arsenic drinking water standards reduced to 10 ppb in Jan. 2006) and must continually be current of developing technologies.

Relationship of course to program outcomes: The contribution of ENVE 120 to program outcomes (a)-(k) or (1) – (11) is summarized in the objective-outcome matrix table

Objective-Outcome Matrix
Objective Addresses Outcome: 1-Slightly 2-Moderately 3-Substantially

Outcome Related Learning Objectives (See course objectives on previous page)	**Outcome 1**	**Outcome 2**	**Outcome 3**	**Outcome 4**	**Outcome 5**	**Outcome 6**	**Outcome 7**	**Outcome 8**	**Outcome 9**	**Outcome 10**	**Outcome 11**
Course Objective 1	2					2		2	1	1	
Course Objective 2	3		3		3						3
Course Objective 3	3		2		1						1
Course Objective 4	3	3	3		3						2
Course Objective 5	3		2		2						2
Course Objective 6	3		2		2						2
Course Objective 7	3		2		2						2
Course Objective 8	3		2		3						3
Course Objective 9	3		3	3	3	3	3	3	3	3	3

Prepared by and date of preparation: K. Tam; May 31, 2006

Department, number and title of course: Department of Chemical and Environmental Engineering ENVE 133- Fundamentals of Air Pollution Engineering

Required/Elective course: Technical Elective for the Chemical Engineering option

Catalog description: Principles, modeling, and design of systems for atmospheric emission control of pollutants such as photochemical smog and by-products of combustion. Effects of air pollution on health.

Prerequisite(s): CHE 114, CHEM 112B, ENVE 171; or consent of instructor.

Textbook(s) and/or other required material:
Air Pollution: Its Origin and Control by Wark, Warner and Davis, 3rd Edition

Course objectives: See column 1 in course matrix next page.

Topics covered: Air pollution terminology, national and state air quality standards, air pollutants and their adverse health effects (toxicity, carcinogenicity, visibility, etc.), adiabatic lapse rate, temperature inversions, basic structure of atmosphere, potential temperature, semi-empirical atmospheric diffusion equation, Gaussian dispersion, plume rise, averaging times, plume trapping, wind-rose, wind speed as a function of height, point/line/area sources and dispersion, definitions of particulate matter, measurement of particulate matter, particulate size distributions, sources of ultrafine/fine/course particulate matter, secondary organic aerosol, ozone formation, alkene/alkane/aromatic/carbonyl atmospheric chemistry, kinetic rate expressions, ozone and NO_x measurement, sources of and control strategies for ozone and particulate matter, indoor air quality, sick building syndrome, radiative forcing, stratospheric ozone depletion.

Class/laboratory schedule: Lecture, 3 hours; discussion, 1 hour.

Assessment methods: Homework: 20%; 1 Midterm: 25%; Design Project: 20%;Final: 35%

Contribution of course to meeting the professional component:
This course focuses on the fundamental aspects of air quality control engineering. The course develops the students ability to understand the chemistry and physics behind atmospheric pollution formation and atmospheric dispersion, provides the key knowledge needed for design of air quality control programs; relates local and regional emissions to air quality degradation including ozone formation, particulate matter (primary and secondary), and visibility. Homeworks, in-class examples, and the class design project develop students design and problem solving skills within given problem constraints (e.g., cost). Contemporary issues from scientific literature (journal reprints) and news media outlets (typically local newspaper articles on air quality in Southern California) are discussed in the class in terms of control/mitigation strategies, air quality pollution control engineering and human health and welfare.

Relationship of course to program outcomes: The contribution of ENVE 133 to program outcomes (a)-(k) or (1) – (11) is summarized in the objective-outcome matrix table

Objective-Outcome Matrix

Objective Addresses Outcome: 1-Slightly 2-Moderately 3-Substantially

Outcome Related Learning Objectives	Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5	Outcome 6	Outcome 7	Outcome 8	Outcome 9	Outcome 10	Outcome 11
Define air pollution, aerosol, primary and secondary pollutant, familiarity with National Ambient Air Quality Standards (NAAQS), identify sources of and health effects for ozone, NOx, SOx, particulate matter, and formaldehyde. Be able to identify and classify a number of critical air pollutants including sulfur, nitrogen and carbon containing species, photochemical oxidants, halogen containing compounds and air toxics.			1			2	2	1	2	3	
Describe the vertical profile of the atmosphere. Understand the driving forces for temperature versus altitude for troposphere, mesosphere, stratosphere, and thermosphere. Be able to discuss thermal structures in atmosphere including adiabatic lapse rate (wet and dry), potential temperature, identification of inversion layers, vertical mixing, familiarity with thermodynamic derivations for temperature profiles	3				2			1		2	1
Familiarity with the semi-empirical atmospheric diffusion equation, eddy correlations, and its application to atmospheric dispersion processes.	3				2			1		2	
Estimate ambient concentrations from point, line and area sources. Estimate wind variation with altitude and plume rise. Account for ground reflection, inversion heights, and multiple sources. Use of atmospheric box models to predict ambient concentrations.	3	2	3		3			3		3	3
Derive the photostationary state. Describe basic VOC-NOx interactions and their impact on ozone formation. Ability to predict atmospheric oxidation routes for alkanes, alkenes, carbonyls, and to a lesser extent aromatics including importance of hydroxyl and nitrate radicals, ozone, hydroperoxy and ROO. radicals in ozone formation. Ability to read ozone isopleth curves, causes of VOC and NOx limited regions, and understanding of the NOx-VOC interplay for ozone formation. Write basic chemical kinetic expressions to describe atmospheric chemistry.	3				1			1		3	2
Explain the sources of atmospheric particulate. Familiarity with size, area, and volume distribution curves, calculate terminal settling velocities, impact of particles on visibility, Understand PM10, PM2.5, PM1 and the sources of each. Discuss secondary aerosol including secondary organic aerosol formation.	3	1	2		2			3		2	3
Discuss possible control strategies for PM and O3	3	3	3		2			3	3	3	3
Discuss concerns with Indoor Air Quality including the Sick Building Syndrome; relationship of outdoor to indoor pollutants	1	1	2		1			2		3	1
Global air quality issues. Discuss causes of global warming/cooling and potential atmospheric implications. Describe processes leading to the Antarctic ozone hole.	3							3		3	1
Work together as a design team to estimate the impacts of expanding urban development on local air quality. Impacts must include cost/benefit analysis and ethical/environmental justice considerations. Present findings in written and oral report.	3	1	2	3	3	3	3	3	2	3	3

Prepared by and date of preparation: D. Cocker; May 31, 2006

Department, number and title of course: Department of Chemical and Environmental Engineering ENVE 134- Technology of Air Pollution Control

Required/Elective course: Technical Elective for the Chemical Engineering option

Catalog description: Processes and design of control technologies for gaseous and particulate pollutants. Methods and design of ambient air quality measurements and air pollution source sampling for both gaseous and particulate pollutants.

Prerequisite(s): ENVE 133

Textbook(s) and/or other required material:
Air Pollution Control Technology: A Design Approach by Cooper and Alley, 3rd Edition Waveland Press, Inc, 2002.

Course objectives: Upon completion of this course, students should be able to:
1. Characterize of atmospheric pollutants. The status, history and regulations of air pollution.
2. Be aware of considerations in designing an air pollution control devices. The application of thermodynamics to derive mass and energy conservation.
3. Understand particulate behavior in fluids. Derivation of the particle terminal velocity in the Stoke's regime and the modification of it to non-Stokes's regime.
4. Understand properties of gases and vapors with regard to control technology
5. Be familiar with theoretical backgrounds of particle collection mechanisms. Advantages, disadvantages of control devices.
6. Understand gaseous pollutants collection mechanisms. Their theoretical backgrounds, advantages, and disadvantages.
7. Understand the mechanisms, theories and applications of pollutant control devices.
8. Design particle collection equipments - Cyclone, Electrostatic precipitator, Baghouse, Wet Scrubber - under a given collection efficiency and resources.
9. Design gas and vapor collection devices - VOC incinerators, Gas adsoprtion beds, Sulfur oxides control scrubbers and nitrogen oxides control equipment.

Topics covered:
1. The overview of the properties and the regulations of air pollutant sources from a stationary source.
2. The characteristics of gaseous and particulate pollutants.
3. Control technologies for pollutants from a stationary source.
4. Design practice for a control equipment.
5. Atmospheric dispersion from an exhaust stack.

Class/laboratory schedule: Lecture, 4 hours.

Assessment methods:

Homework	30 %
Midterm Exams	35 %
Final Project	35 %

Contribution of course to meeting the professional component:
This is the key design course for air pollution emphasis environmental engineering students. The course focuses on design on controls (microscale) for chemical plants, power plants, cement plants, mobile sources, etc. by combining the fundamental chemistry and physics covered in ENVE 133 with aspects of transport phenomena (CHE 114, CHE 120, CHE 116) to identify cost-effective, efficient

control strategies for reactive organic gases and particulate matter. This course emphasizes contemporary emissions control strategies for gases and particulate matter with the students homeworks and design projects focusing on design of reasonable emission controls while discussing benefits/penalties of employing a variety of different control equipment. This course develops the students basic problem solving and design skills within physically and economically constrained systems.

Relationship of course to program outcomes: The contribution of ENVE 134 to program outcomes (a)-(k) or (1) – (11) is summarized in the objective-outcome matrix table

Objective-Outcome Matrix

Objective Addresses Outcome: 1-Slightly 2-Moderately 3-Substantially

Outcome Related Learning Objectives	**Outcome 1**	**Outcome 2**	**Outcome 3**	**Outcome 4**	**Outcome 5**	**Outcome 6**	**Outcome 7**	**Outcome 8**	**Outcome 9**	**Outcome 10**	**Outcome 11**
Characteristics of atmospheric pollutants. The status, history and regulations of air pollution.	0	0	0	0	0	1	0	3	0	3	1
Considerations in designing an air pollution control devices. The application of thermodynamics to derive mass and energy conservation.	3	1	3	0	3	0	0	0	0	0	0
Understanding particulate behavior in fluids. Derivation of the particle terminal velocity in the Stoke's regime and the modification of it to non-stokes's regime.	2	0	0	0	3	0	0	0	0	0	0
Properties of gases and vapors with regard to control technology	2	0	0	0	3	0	0	0	0	0	0
Theoretical backgrounds of particle collection mechanisms. Advantages, disadvantages of control devices.	3	0	2	0	3	0	0	1	0	1	0
Gaseous pollutants collection mechanisms. Their theoretical backgrounds, advantages, and disadvantages.	3	0	2	0	3	0	0	1	0	1	0
The mechanisms, theories and applications of pollutant control devices.	3	0	2	0	3	0	1	0	0	0	0
Design particle collection equipments - Cyclone, Electrostatic precipitator, Baghouse, Wet Scrubber - under a given collection efficiency and resources.	2	2	3	0	3	0	1	1	0	1	1
Design gas and vapor collection devices - VOC incinerators, Gas adsorption beds, Sulfur oxides control scrubbers and nitrogen oxides control equipment.	2	2	3	0	3	0	1	1	0	1	1

Prepared by and date of preparation: S. Lee; May 31, 2006