CHEMICAL ENGINEERING
College of Engineering

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Graduate Advisor: Chih-Cheng Lo

Environmental Technology Advisor: Sergio Mendez

General Education Advising: Academic Advising - Horn Center

Career Possibilities

Chemical Engineer • Process Engineer • Automation Control Engineer • Chemical Research Engineer • Chemical Test Engineer • Biochemical Engineer • Biomedical Engineer • Technical Sales • Management • Technical Writer • Quality Control Specialist • Consultant • Safety Engineer • Environmental Engineer • (Some of these careers require additional education or experience. For more information, see www.careers.csulb.edu.)

Introduction

Chemical engineering is a major that opens the way for many career opportunities. As the name implies, chemical engineers must build a foundation on engineering, science, and math while specializing in the application of chemistry to engineering systems. This is a versatile major that also encourages students to take courses from the other engineering disciplines as well as the biological sciences. In general, chemical engineers integrate their broad knowledge and analytical skills to design, implement and optimize chemical processes that convert raw materials into valuable products in a sustainable manner. Chemical engineers ensure that processes are operated safely and economically with minimum energy consumption and waste emission. Many of our graduates find career opportunities in traditional industries such as petroleum refining, energy production, chemical manufacturing and pharmaceuticals. Because of their diverse technical skill set, our graduates are increasingly finding employment in emerging industries such as alternative energy, biomedical engineering, environmental engineering, semiconductors, materials, and nanotechnology.

Program Educational Objectives

The Chemical Engineering bachelor degree program's educational objective statement is directed towards the career accomplishments and expectations of the alumni. The objectives of the program are that recent alumni become successful in their professional careers, and that they continue on a path of professional development.

The Bachelor of Science in Chemical Engineering program objectives are to produce well-rounded graduates who, after entering the chemical engineering practice, will progress to leadership roles by:

- Applying the knowledge, principles, and skills of chemical engineering to the solution of complex engineering problems;
- Practicing safety, sustainability, and ethics throughout their professional careers;
- Communicating effectively and working collaboratively in multidisciplinary teams;
- Pursuing life-long learning through continued education, professional registration, and participation in professional organizations.

The faculty members of the Department of Chemical Engineering strive to continuously improve the program and the curriculum as well as laboratory facilities to ensure the professional career success of our recent graduates. The goal is to prepare students for a wide range of career routes that use chemical engineering principles with a solid foundation in engineering, math, science, and societal awareness. The scope of this program is broadened by courses from general education as well as specialized technical elective courses in chemical engineering and other engineering disciplines. Students develop teamwork skills and gain interdisciplinary experience particularly in laboratory courses, lecture courses with laboratory components, and the capstone design class that require team projects. This program provides ample opportunities for students to develop communication skills such as oral and poster presentations as well as written technical reports. Students are encouraged to participate in life-long learning activities such as professional meetings on or off campus and field trips. The goal is to have a comprehensive, student-centered program that can allow us to meet the educational objectives.

Chemical Engineering Advisory and Development Council

The Department of Chemical Engineering Advisory and Development Council, consisting of outstanding engineers and executives from industry and government in Southern California, provides guidance to our program. Its mission is to advise and assist in developing the Department and to support its efforts to serve students, the community, and industry. This liaison between the University and industry ensures that industry concerns are addressed in our curricula and provides career guidance for our graduates.

ABET Accreditation

The Bachelor of Science in Chemical Engineering is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

Other Related Programs

Students interested in obtaining a Minor in Environmental Engineering should refer to the College of Engineering section of this catalog. Students who take required Chemistry courses are most likely eligible for Minor in Chemistry degree. See the College of Natural Science and Mathematics section of this catalog.

Students wishing to pursue advanced study may be interested in the College of Engineering's Master of Science in Engineering (MSE) degree. Thesis work may be supervised

by chemical engineering faculty. For detailed MSE requirements, see the College of Engineering section of this catalog.

Grade Requirements

In addition to other University requirements, all students must obtain a grade of "C" or better in each prerequisite for any chemical engineering course. Also, required Written English (GE A1), Speech (GE A2), and Interdisciplinary (IC) courses must be taken for a letter grade, not Credit/No Credit.

Undergraduate Programs

Bachelor of Science In Chemical Engineering (120 units)

Major Declaration

Freshmen admission to engineering majors is to a 'pre-major' status (i.e., Pre-Chemical Engineering). Continuation in the major will be subject to meeting specific lower division course and GPA requirements at CSULB that indicate the student's ability to succeed and complete the major. Transfer applicants and CSULB students seeking admission into Chemical Engineering must also meet similar major specific requirements. To become fully admitted into the Chemical Engineering major, all prospective students (i.e., pre-majors, undeclared, major changes) must have a minimum cumulative 2.5 GPA and complete the following lower-division courses with a minimum grade of "C" prior to earning 60 units:

Core Lower-Division Major Requirements:
MATH 122 (Calculus I), MATH 123 (Calculus II), PHYS 151 (Mechanics and Heat), CHEM 111A (General Chemistry)

General Education Foundations Courses:
Written and Oral Communication

Degree Progress

Students must complete the following requirements within one calendar year of declaring the major. Some students may need to take courses during Summer Session to meet these requirements. At the end of the year, students who have not met the requirements must either declare another major or meet with an Academic Advisor to determine if the student's performance in the courses merits an additional semester to complete.

First-time Freshmen: A grade of "C" or better must be achieved in MATH 122 within one calendar year.

Transfer Students: A grade of "C" or better must be achieved in MATH 123 and PHYS 151 within one calendar year.

Requirements

A grade of "C" or better must be achieved in all required courses listed below.

Lower Division:

Take all the following courses:

CH E 200 Chemical Engineering Fundamentals (3)
Prerequisites: CHEM 111A, MATH 122, PHYS 151 all with a grade of "C" or better.

CH E 210 Computer Methods in Chem Engineering (3)
Prerequisite/Corequisite: MATH 123

CH E 220 Chemical Engineering Thermodynamics I (3)
Prerequisite: CH E 200 with a grade of "C" or better.

CHEM 111A General Chemistry (5)
Prerequisites: A passing score on the Chemistry Placement Examination and a "C" or better in MATH 113 or MATH 117 or MATH 119A or MATH 122. One year of high school chemistry is strongly recommended.

CHEM 111B General Chemistry (5)
Prerequisite: CHEM 111A and MATH 113 or MATH 115 or MATH 117 or MATH 119A or MATH 122 all with a grade of "C" or better.

C E 205 Analytical Mechanics I (Statics) (3)
Prerequisite: PHYS 151 with a grade of "C" or better.
Prerequisite/Corequisite: MATH 123.

ENGR 101 Introduction to Engineering Profession (1)
Prerequisite/Corequisite: MATH 111 or MATH 113 or MATH 122

ENGR 102 Academic Success Skills (1)
Prerequisite: ENGR 101 with a grade of "C" or better.

CH E 100 Introduction to Chemical Engineering (1)
Prerequisite: None.

MATH 122 Calculus I (4)
Prerequisite: Appropriate MDPT placement or a grade of "C" or better in MATH 111 and MATH 113, or a grade of "C" or better in MATH 117.

MATH 123 Calculus II (4)
Prerequisite: A grade of "C" or better in MATH 122.

MATH 224 Calculus III (4)
Prerequisite: A grade of "C" or better in MATH 123 or MATH 222.

PHYS 151 Mechanics and Heat (4)
Prerequisite/Corequisite: MATH 122.

Take one of the following choices:

PHYS 152 Electricity and Magnetism (4)
Prerequisite: PHYS 151; Prerequisite/Corequisite: MATH 123.

or both of the following:

EE 210 Electro-Magnetic Foundations in EE (3)
Prerequisite: PHYS 151 with a grade of "C" or better.
Corequisites: MATH 123, EE 210L.

EE 210L Electro-Magnetic Foundations in EE Lab (1)
Corequisite: EE 210

Take one of the following choices:

CHEM 220A, CHEM 223A, CHEM 220B, and CHEM 223B

or

CHEM 227 and one of the following: BIOL 200, BIOL 205, or BIOL 211

Upper Division:

Take all the following courses:

CH E 310 Chemical Engineering Thermodynamics II (3)
Prerequisites: CHE 210, CHE 220 all with a grade of "C" or better.

CH E 320 Fluids (3)
Prerequisites: CH E 200, C E 205 all with a grade of "C" or better.

CH E 330 Separation Processes (3)
Prerequisite/Corequisite: CHE 310

CH E 420 Heat and Mass Transport (3)
Prerequisites: CHE 310, CHE 320 all with a grade of "C" or better.

CH E 430 Chemical Reactor Kinetics (3)
Prerequisite: CHE 310

CH E 440 Chemical Engineering Laboratory I (2)
Prerequisites: CHE 320, CHE 330 all with a grade of "C" or better.

CH E 450 Chemical Engineering Laboratory II (2)
Prerequisites: CHE 440 with a grade of "C" or better.
Prerequisite(s)/Corequisite(s): CHE 420, CHE 430, and CHE 460

CH E 460 Chemical Process Control (3)
Prerequisites: CHE 420, CHE 430, and (MATH 370A or CHE 480) all with a grade of "C" or better

CH E 470 Chemical Engineering Design (4)
Prerequisites: CHE 330, CHE 420, CHE 430 all with a grade of "C" or better.

CHEM 375 Physical Chemistry for Engineers(3)
Prerequisites: MATH 123; PHYS 151 and either PHYS 152 or EE 210/EE 210L; CH E 220; CHEM 111A/B; and CHEM 220A or CHEM 227, all with grades of "C" or better. CH E 310 is strongly recommended.

MATH 370A Applied Mathematics I (3)
Prerequisites: A grade of "C" or better in MATH 123. Exclude freshmen.

Take six units from the following courses:
CHE 300, CHE 415, CHE 431, CHE 432, CHE 433, CHE 437, CHE 445, CHE 455, CHE 475, CHE 480, CHE 485, CHE 490;

All students are encouraged to attempt FE Exam. Those who pass the FE Exam before graduation can waive 3 units of elective course.

Minor in Environmental Engineering

For requirements, see the description in the College of Engineering section of this catalog.

Chemical Engineering Courses (CH E)

LOWER DIVISION

100. Introduction to Chemical Engineering (1)

Chemical engineering as a profession. Nature of profession and career opportunities. Emerging frontiers of chemical engineering.

(Lecture 1 hour) Letter grade only (A-F).

200. Chemical Engineering Fundamentals (3)

Prerequisites: CHEM 111A, MATH 122, PHYS 151 all with a grade of "C" or better.

Dimensional analysis of units, steady and transient balances of mass, momentum and energy, the mathematical solution of chemical engineering problems.

(Lecture-problems 3 hrs) Letter grade only (A-F). Same course as CHE 200H. Not open for credit to students with credit in CHE 200H.

200H. Chemical Engineering Fundamentals (3)

Prerequisites: CHEM 111A, MATH 122, PHYS 151 all with a grade of "C" or better.

Dimensional analysis of units, steady and transient balances of mass, momentum and energy, the mathematical solution of chemical engineering problems

Letter grade only (A-F). CHE 200H is open only to students in the Engineering Honors Program. Additional assignments/projects adding depth to the course materials required for Engineering Honors students. Not open for credit to students with credit in CHE 200. (Lecture-problems 3 hours)

210. Computer Methods in Chemical Engineering (3)

Prerequisite/corequisite: MATH 123

Beginning programming and techniques of numerical analysis applied to typical problems in chemical engineering.

(Lecture-problems 2 hours, lab 3 hours) Letter grade only (A-F).

220. Chemical Engineering Thermodynamics I (3)

Prerequisite: CH E 200 with a grade of "C" or better.

Applications of the first and second laws of thermodynamics to chemical processes. Concepts of heat, work, and energy. Energy balances in batch and flow processes, with and without chemical reaction. Gas behavior, phase change, vapor pressure, humidity.

(Lecture-problems 3 hours) Letter grade only (A-F).

UPPER DIVISION

300. The Chemical Industry (3)

Prerequisite: CH E 200 with a grade of "C" or better.

Survey of industrial chemical processing techniques and the activities of engineers in this area, illustrated by field trips, speakers, professional society meetings, films, readings, etc.

(Lecture 3 hours) Letter grade only (A-F).

310. Chemical Engineering Thermodynamics II (3)

Prerequisites: CH E 210, CH E 220 all with a grade of "C" or better.

Analysis and design of process equipment and systems using thermodynamics. Turbines, compressors, power plants, refrigeration cycles. Phase equilibria and nonideal solution behavior. Chemical reaction equilibria and heat effects.

(Lecture-problems 3 hours) Letter grade only (A-F). Not open for credit to students with credit in CHE 410.

320. Fluids (3)

Prerequisites: CH E 200, C E 205 all with a grade of "C" or better.

Study of the deformation and flow of fluids, both liquids and gases, with applications to chemical engineering.

(Lecture-problems 3 hours) Letter grade only (A-F).

330. Separation Processes (3)

Prerequisite/Corequisite: CHE 310

Material and energy balances around multi-stage mass transfer unit operations. Calculation and graphical estimation of ideal number of stages. Binary and multicomponent liquid-liquid extraction, distillation and gas absorption. Model equilibrium staged separation processes with chemical process simulation software.

(Lecture-problems 2 hours, lab 3 hrs) Letter grade only (A-F). Same course as CHE 330H. Not open for credit to students with credit in CHE 330H.

330H. Separation Processes (3)

Prerequisite/Corequisite: CHE 310

Material and energy balances around multi-stage mass transfer unit operations. Calculation and graphical estimation of ideal number of stages. Binary and multicomponent liquid-liquid extraction, distillation and gas absorption. Model equilibrium staged separation processes with chemical process simulation software.

Letter grade only (A-F). CHE 330H is open only to students in the Engineering Honors Program. Additional assignments/projects adding depth to the course materials required for Engineering Honors students. Not open for credit to students with credit in CHE 330. (Lecture-problems 2 hours, laboratory 3 hours)

415./515. Occupational and Environmental Safety Engineering and Management (3)

Prerequisite: CHEM 227 all with a grade of "C" or better or consent of instructor.

Safety analysis and management, legislation, regulations

and standards; toxicology and personal protective equipment; fire hazards; noise control; electrical safety; container and spill management; statistical analysis. Extra requirements for graduate students.

(Lecture-problems 3 hours) Letter grade only (A-F).

420. Heat and Mass Transport (3)

Prerequisites: CHE 310, CHE 320 all with a grade of "C" or better.

Heat exchange by conduction, convection and radiation. Diffusion in fluids and solids. Simultaneous heat and mass transport.

(Lecture-problems 2 hours, lab 3 hours) Letter grade only (A-F).

426. Engineering Properties of Polymers (3)

Prerequisites: CHE 320, or CE 335, or MAE 333 all with a grade of "C" or better.

Analysis of mechanical tests of polymers in the glassy, rubbery, and fluid states. Glass transition, amorphous and crystalline materials. Mechanical behavior of thermoplastics, vulcanized rubber, and thermosets. Viscoelastic properties, failure mechanics, yielding of polymers. Fatigue and fracture mechanics for polymers.

Letter grade only (A-F). (Lecture-Problems 3 hours).

430. Chemical Reactor Kinetics (3)

Prerequisite: CHE 310

Mechanism and rate law of chemical reaction, temperature and pressure effects, homogeneous and heterogeneous reactions and application to reactor design, catalysts.

(Lecture-problems 2 hours, lab 3 hours) Letter grade only (A-F).

431./531. Heterogeneous Catalysts (3)

Prerequisite: CHE 430 with a grade of "C" or better or consent of instructor.

Basic principles of solid catalysts and solid catalyzed reactions. Proper choice of catalysts and how to solve catalyst-related problems in chemical engineering. Development of chemical processes that utilize innovative catalysts. Graduate students will need to do more assignments.

Letter grade only (A-F). (Lecture-problems 3 hours).

432./532. Microfabrication and Microfluidics Technology (3)

Prerequisites: CHE 320, CHEM 227, (MATH 370A or CHE 480) all with a grade of "C" or better or consent of instructor.

Fundamentals of major microfabrication techniques for device construction and microfluidics technology. Topics: photolithography, wet/dry etching, metal/dielectric deposition, soft lithography, diffusion/mixing/separation in microfluidic devices, and chip-to-world interfaces. Graduate students need to do more assignments.

Letter grade only (A-F). (Lecture-problems 3 hours).

433./533. Green Engineering I: Alternative Energy (3)

Prerequisites: CHE 220. CHE 330, CHE 310 all with a grade of "C" or better or consent of instructor.

Aspects of green engineering. Sustainable liquid fuels: ethanol and biodiesel from renewable sources. Photovolaic solar devices: semiconductor- and polymer-based solar cells. Solar array collectors: power cycles to convert heat to electrical power. Hydrogen fuel cells: electrochemical cells, and proton exchange membranes. Graduate students will submit final written reports.

Letter grade only (A-F). (Lecture-Problems 3 hours).

437./537. Materials Purification Processes (3)

Prerequisite: CH E 330, CHE 420 all with a grade of "C" or better or consent of instructor.

Rate-controlled separation processes such as membrane separations, pressure swing adsorption, molecular sieve separation, supercritical fluid extraction, reverse osmosis, and spray drying.

Additional projects required for CH E 537. (Lecture-problems 3 hours) Letter grade only (A-F).

439. Fuel Cell Fundamentals and Theory (3)

Prerequisites: MAE 322 and 330; or CHEM 371A all with a grade of "C" or better

Theory of electrochemistry. Survey of electrochemical fuel cell systems. Fundamentals of electrochemical thermodynamics, electrochemical kinetics, charge transport, and mass transport. Review of fuel cell modeling and characterization techniques. Atomic level density functional theory (DFT) calculations of a fuel cell catalyst reaction. .

Letter grade only (A-F). (Lecture-problem 3 hours).

440. Chemical Engineering Laboratory I (2)

Prerequisites: CHE 320, CHE 330 all with a grade of "C" or better.

Laboratory study of fluid mechanics, separation processes and thermodynamics. Experimental design and analysis and preparation of engineering reports.

(Laboratory 6 hours) Letter grade only (A-F).

445./545. Pollution Prevention (3)

Prerequisite: CH E 330 with a grade of "C" or better.

Pollution prevention strategies in chemical industry. Hierarchical approach of waste minimization. Life cycle analyses of wastes. Identification of pollution source. Environmentally compatible materials. Unit operations for minimizing waste. Economics of pollution prevention. Extra requirement for graduate students.

(Lecture-problems 3 hours) Letter grade only (A-F).

450. Chemical Engineering Laboratory II (2)

Prerequisites: CHE 440 with a grade of "C" or better. Prerequisite(s)/Corequisite(s): CHE 420, CHE 430, and CHE 460

Apply fundamental knowledge of heat transfer, chemical separations, process control and chemical kinetics to practical experiments. Remote data acquisition and control of process equipment. Design experiments to collect data, and perform data analysis. Written reports and oral/poster presentations.

(Laboratory 6 hours) Letter grade only (A-F).

455./555. Environmental Compliance (3)

Prerequisite: CHEM 227 with a grade of "C" or better or consent of instructor.

Physical and chemical properties of hazardous materials and wastes. Environmental hazards. An examination of environmental laws, regulations and standards dealing with storage, transportation, treatment and disposal of hazardous wastes. Emergency planning and preparedness. Extra requirement for graduate students: term papers or projects.

(Lecture-problems 3 hours) Letter grade only (A-F).

460. Chemical Process Control (3)

Prerequisites: CHE 420, CHE 430, and (MATH 370A or CHE 480) all with a grade of "C" or better.

Control theory and practice, instrumentation, system responses, transfer functions, feed-back control, and stability as applied to chemical engineering processes.

(Lecture-problems 2 hours, lab 3 hours) Letter grade only (A-F).

470. Chemical Engineering Design (4)

Prerequisites: CHE 330, CHE 420, CHE 430 all with a grade of "C" or better.

One-semester capstone design course fulfilling integrative learning. Design and optimization of chemical processing plants using analytical methods and modern computer simulation tools. Chemical process equipment sizing. Economic, ethical and safety issues considered. Teamwork, oral presentations and written reports are required.

(Lecture-problems 3 hours, problem-design session 3 hrs) Letter grade only (A-F). Same course as CHE 470H. Not open for credit to students with credit in CHE 470H.

470H. Chemical Engineering Design (4)

Prerequisites: CHE 330, CHE 420, CHE 430 all with a grade of "C" or better.

One-semester capstone design course fulfilling integrative learning. Design and optimization of chemical processing plants using analytical methods and modern computer simulation tools. Chemical process equipment sizing. Economic, ethical and safety issues considered. Teamwork, oral presentations and written reports are required.

Letter grade only (A-F). CHE 470H is open only to students in the Engineering Honors Program. Additional assignments/projects adding depth to the course materials required for Engineering Honors students. Not open for credit to students with credit in CHE 470. (Lecture-problems 3 hours, problem-design session 3 hours)

475./575. Environmental Pollution (3)

Prerequisite: CHEM 220A or CHEM 227 all with a grade of "C" or better or consent of instructor.

Application of chemistry to the problems of pollution. Graduate students have additional assignments.

(Lecture-problem 3 hours) Letter grade only (A-F).

480./580. Theoretical Methods in Chemical Engineering (3)

Prerequisites: CH E 420, CHE 430 all with a grade of "C" or better.

Simulation and optimization of chemical engineering processes by mathematical formulation and computer modeling.

Extra requirements for graduate students: term papers or projects. (Lecture-problems 3 hours) Letter grade only (A-F).

485./585. Air Pollution (3)

Prerequisite: CH E 475 or CE 364 all with a grade of "C" or better or consent of instructor.

Air pollution chemistry; control strategies; origin of pollutants; meteorology; vapor dispersion models; control principles for particulates, sulfur dioxide, and nitrogen oxides.

Extra requirements for graduate students: term papers or projects. (Lecture-problems 3 hrs) Letter grade only (A-F).

490. Special Problems (1-3)

Prerequisite: Consent of instructor.

Assigned topics in technical literature or laboratory projects and reports on same.

Letter grade only (A-F).

GRADUATE LEVEL

505. Advanced Chemical Engineering Thermodynamics (3)

Prerequisite: CHE 310 or equivalent course

Modern equations of state. Theoretical treatment of non-ideal multiphase equilibria. Statistical mechanics and ensembles to describe thermodynamic properties and fundamental property relations. Non-equilibrium thermodynamics with applications to chemical reaction kinetics. Optimization of power and refrigeration cycles.

Letter grade only (A-F). (Lecture-problem 3 hours).

515./415. Occupational and Environmental Safety Engineering and Management (3)

Prerequisite: CHEM 227 all with a grade of "C" or better or consent of instructor.

Safety engineering and management, legislation, regulations and standards; toxicology and personal protective equipment; fire hazards; noise control; electrical safety; system safety analysis; container and spill management; use of computer systems and statistical methods.

Extra requirements for graduate students: term papers or projects. (Lecture-problems 3 hours) Letter grade only (A-F).

520. Advanced Transport Phenomena (3)

Prerequisites: CH E 320, CHE 420, CHE 430 all with a grade of "C" or better.

Application of differential and integral mass, momentum and energy balances to chemical engineering processes. Analysis of fluid flow, heat transfer, diffusion and chemical reaction in various unit operations.

(Lecture-Problems 3 hours) Letter grade only (A-F).

530. Advanced Reactor Kinetics (3)

Prerequisite: CH E all with a grade of "C" or better.

Modeling of chemical reactors; effects of multiple phases, mixing, adsorption, diffusion and catalysts on reactor performance.

(Lecture-Problems 3 hrs) Letter grade only (A-F).

531./431. Heterogeneous Catalysts (3)

Prerequisite: CHE 430 with a grade of "C" or better or consent of instructor.

Basic principles of solid catalysts and solid catalyzed reactions. Proper choice of catalysts and how to solve catalyst-related problems in chemical engineering. Development of chemical processes that utilize innovative catalysts. Graduate students will need to do more assignments.

Letter grade only (A-F). (Lecture-Problems 3 hours)

532./432. Microfabrication and Microfluidics Technology (3)

Prerequisites: CHE 320, CHEM 227, MATH 370A or CHE 480 all with a grade of "C" or better or consent of instructor.

Fundamentals of major microfabrication techniques for device construction and microfluidics technology. Topics: photolithography, wet/dry etching, metal/dielectric deposition, soft lithography, diffusion/mixing/separation in microfluidic devices, and chip-to-world interfaces. Graduate students need to do more assignments.

Letter grade only (A-F). (Lecture-Problems 3 hours).

533./433. Green Engineering I: Alternative Energy (3)

Prerequisites: CHE 220. CHE 330, CHE 310 all with a grade of "C" or better or consent of instructor.

Aspects of green engineering. Sustainable liquid fuels: ethanol and biodiesel from renewable sources. Photovolaic solar devices: semiconductor- and polymer-based solar cells. Solar array collectors: power cycles to convert heat to electrical power. Hydrogen fuel cells: electrochemical cells, and proton exchange membranes. Graduate students will submit final written reports.

Letter grade only (A-F). (Lecture-Problems 3 hours).

537./437. Materials Purification Processes (3)

Prerequisites: CH E 330, CH E 420 all with a grade of "C" or better. or consent of instructor.

Rate-controlled separation processes such as membrane separations, pressure swing adsorption, molecular sieve separation, supercritical fluid extraction, reverse osmosis, and spray drying.

Additional projects required for CH E 537. (Lecture-problems 3 hours) Letter grade only (A-F).

545./445. Pollution Prevention (3)

Prerequisite: CH E 330 with a grade of "C" or better.

Pollution prevention strategies in chemical industry; hierarchical approach waste minimization; life cycle analyses of wastes; identification of pollution source; environmentally compatible materials; unit operations for minimizing waste; economics of pollution prevention.

Extra requirement for graduate students. (Lecture-problems 3 hours) Letter grade only (A-F).

555./455. Environmental Compliance (3)

Prerequisite: CHEM 227 with a grade of "C" or better or consent of instructor.

Physical and chemical properties of hazardous materials and wastes. Environmental hazards. An examination of environmental laws, regulations and standards dealing with storage, transportation, treatment and disposal of hazardous wastes. Emergency planning and preparedness.

Extra requirement for graduate students: term papers or projects. (Lecture-problems 3 hours) Letter grade only (A-F).

560. Advanced Chemical Process Control (3)

Prerequisite: One of the following: CH E 460, E E 370/L, E E 411, EE 470, EE 471, EE 511, MAE 376, E T 492 all with a grade of "C" or better or consent of instructor.

Principles and practices of controller selection and tuning, advanced control loops, model predictive control, decoupling, hands-on experience of control loop design and implementation using Labview.

(Lecture-Problems 3 hours) Letter grade only (A-F).

575./475. Environmental Pollution (3)

Prerequisite: CHEM 220A or CHEM 227 all with a grade of "C" or better or consent of instructor.

Application of chemistry to the problems of pollution. Graduate students have additional assignments.

(Lecture-problem 3 hours). Letter grade only (A-F).

580./480. Theoretical Methods in Chemical Engineering (3)

Prerequisites: CH E 420, CHE 430 all with a grade of "C" or better.

Simulation and optimization of chemical engineering processes by mathematical formulation and computer modeling.

Extra requirements for graduate students: term papers or projects. (Lecture-problems 3 hours) Letter grade only (A-F).

585./485. Air Pollution (3)

Prerequisite: CH E 475 or CE 364 all with a grade of "C" or better or consent of instructor.

Air pollution chemistry; control strategies; origin of pollutants; meteorology; vapor dispersion models; control principles for particulates, sulfur dioxide, and nitrogen oxides.

Extra requirement for graduate students: term papers or projects. (Lecture-problems 3 hrs) Letter grade only (A-F).

697. Directed Research (1-3)

Prerequisite: Graduate standing.

Individual research or intensive study under the guidance of a faculty member on theoretical or experimental problems in chemical engineering.

(Independent Study) Letter grade only (A-F).

698. Thesis or Industrial Project (2-6)

Prerequisite: Advancement to Candidacy.

Preparation and completion of a thesis or industrial project in chemical engineering.

May be repeated to a maximum of 6 units.