Department of Chemical and Biological Engineering

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Interim Chair:
John Kallend

Liaison, Environmental Management Program:
Fouad Teymour

The mission of the Department of Chemical and Biological Engineering is to meet the present and future needs of society and industry by providing state-of the-art education and research programs. In order to accomplish this mission, the department provides graduate students with:

- Fundamental knowledge and design capability in biological engineering, chemical engineering, gas engineering, and food process engineering.
- Advanced research programs in core competency areas.
- Knowledge of industrial ecology/design for the environment
- Understanding of ethical, economic and social issues that influence intellectual technological choices.
- Leadership and communication skills.
- Lifelong learning capabilities.

Degrees Offered

Master of Biological Engineering
Master of Chemical Engineering
Master of Science in Chemical Engineering
Doctor of Philosophy in Chemical Engineering

With the National Center for Food Safety and Technology:
Master of Food Process Engineering
Master of Science in Food Process Engineering

Dual Degree Programs

Master of Science in Computer Science/Master of Chemical Engineering

Certificate Programs

Biological Engineering
Current Energy Issues
Food Process Engineering
Food Processing Specialist
Particle Processing
Pharmaceutical Engineering
Polymer Science and Engineering
Process Operations Management

Interdisciplinary Programs

Energy/Environment/Economics (E^3) specialization

With the Stuart School of Business:
Master of Science in Environmental Management (degree is offered by the Stuart School of Business)

Research Centers

Center for Electrochemical Science and Engineering: Jai Prakash, director

Center of Excellence in Polymer Science and Engineering: David Venerus, director

Center for Molecular Study of Condensed Soft Matter: Jay Schieber, director

Center for Complex Systems and Dynamics: Fouad Teymour, director

Research Facilities

Research facilities of the department include:

- Biochemical Engineering Lab
- Biointerfaces Lab
- Biomaterials Lab
- Center for Electrochemical Science and Engineering Lab
- Center of Excellence in Polymer Science and Engineering Lab
- Computational Fluid Dynamics Lab
- Fuel Cell Lab
- Fuel Cell Battery Lab
- Fluidization Lab
- Gas Processing Lab
- Interfacial Phenomena Lab
- Light Scattering Lab
- Multiphase Flow and Fluidization Lab
- Particle Technology Lab
- Pharmaceutical and Crystallization Lab
- Polymer Characterization Lab
- Polymer Reaction Engineering Lab
- Porous Media and Core Analysis Lab
- Process Control & Optimization Lab
- Process Modeling, Monitoring and Control Lab
- Rheology Lab
- Riser Lab
- Solar Hydrogen Lab
- Solar/Photo Voltaic Lab

The computational facilities of the department include the Advanced Computer Laboratory, and the computer facilities of each research group. There are 26 Pentium-based computers in the PC lab that can access the workstations, creating a 26-seat computational lab for instructional activities at the graduate and undergraduate levels. All computers are connected to the IIT computer network by ethernet. Both the PCs and workstations access the multimedia system to provide data visualization and high-quality presentations. Each research lab also has specialized computer facilities. The computational capability for the department is provided by three servers that include both Linux and Windows. Students also have access to the universitys Computing and Network Services.

Research Areas

Faculty members conduct numerous projects in the departments core areas of research competency:

Energy and Sustainability

- Fuel Cells
- Fluidization and Gasification
- Hybrid Systems

Biological Engineering

- Molecular Modeling
- Diabetes
- Biomedical and Pharmaceutical Engineering

Advanced Materials

- Interfacial and Transport Phenomena
- Nanotechnology
- Polymers
- Biomaterials

Systems Engineering

- Complex Systems
- Advanced Process Control
- Process Monitoring

Faculty

Javad Abbasian (abbasian@iit.edu), GTI Associate Professor of Chemical Engineering. B.S., Abadan Institute of Technology (Iran); M.S., Ph.D., Illinois Institute of Technology. Research interests: High temperature gas cleaning, pollution control and solid waste management; gas separation and purification; and process design and development.

Hamid Arastoopour (arastoopour@iit.edu), Henry R. Linden Professor of Energy and Director of WISER. B.S., Abadan Institute of Technology (Iran); M.S., Ph.D., Illinois Institute of Technology. Research interests: Computational fluid dynamics (CFD) of multiphase flow, fluidization, flow in porous media, particle technology and material processing, and environmental engineering problems.

Donald J. Chmielewski (chmielewski@iit.edu), Associate Professor of Chemical Engineering and Associate Chair, Graduate Affairs. B.S., Illinois Institute of Technology; M.S., Ph.D., University of CaliforniaLos Angeles. Research interests: Advanced process control; fuel cell system design and control.

Ali Cinar (cinar@iit.edu), Professor of Chemical Engineering, Dean of the Graduate College and Associate Vice President for Research. B.S., Robert College (Turkey); M.S., Ph.D., Texas A&M. Research interests: Fundamental methodology and tools used in various applications including: polymer reaction engineering, food processing, medicine and biotechnology.

Dimitri Gidaspow (gidaspow@iit.edu), Professor Emeritus. B.S., City College of New York; M.S., Polytechnic Institute of Brooklyn; Ph.D., Illinois Institute of Technology. Research interests: Hydrodynamic theories of fluidization and multiphase flow, gas-solid transport, and hydrodynamic models for slurry bubble column reactors.

Nancy W. Karuri (nkaruri1@iit.edu), Assistant Professor of Chemical Engineering. B. E., University of New South Wales, Australia; Ph.D., University of Wisconsin-Madison. Research Interests: tissue engineering, biomimetic scaffolds, extracellular matrix assembly.

Satish Parulekar (parulekar@iit.edu), Professor of Chemical Engineering. B.S., University of Bombay; M.S., University of Pittsburgh; Ph.D., Purdue University. Research interests: Biochemical engineering and chemical reaction engineering.

Victor H. Prez-Luna (perezluna@iit.edu), Associate Professor of Chemical Engineering. B.S., M.S. Universidad de Guadalajara (Mexico); Ph.D., University of Washington. Research interests: Surface analysis and modification, biomaterials and biosensors, and tissue engineering

Jai Prakash (prakash@iit.edu), Interim Chair,Professor of Chemical Engineering, Director, Center for Electrochemical Science and Engineering and Interim Chairman. B.S., M.S., Ph.D., University of Delhi; Ph.D., Case Western Reserve University. Research interests: Electrochemistry, materials development, and batteries and fuel cells.

Vijay K. Ramani (ramani@iit.edu) Assistant Professor of Chemical Engineering. B.E. Annamalai University (India); Ph.D., University of Connecticut. Research interests: Hybrid materials for sustainable chemical and electrochemical energy conversion, hydrogen and liquid fueled polymer electrolyte fuel cells (PEFCs), degradation mitigation strategies in PEFCs, and development of educational modules to demonstrate sustainable energy economy concepts.

Jay D. Schieber (schieber@iit.edu), Professor of Chemical Engineering. B.S., University of Illinois-Urbana; Ph.D., University of Wisconsin, Madison. Research interests: Kinetic theory, polymer rheology predictions, and thermal conductivity measurements.

Fouad A. Teymour (teymour@iit.edu), Johnson Polymer Professor of Chemical Engineering. B.S., M.S., Cairo University; Ph.D., University of Wisconsin-Madison. Research interests: Polymer reaction engineering, mathematical modeling, nonlinear dynamics, and complexity and complex systems.

David C. Venerus (venerus@iit.edu), Hyosung S.R. Cho Professor of Chemical and Biological Engineering and Director, Center of Excellence in Polymer Science and Engineering. B.S., University of Rhode Island; M.S., Ph.D., Pennsylvania State University. Research interests: Transport phenomena in complex materials, Forced Rayleigh Scattering, polymer rheology, and polymer foam processing.

Darsh T. Wasan (wasan@iit.edu), Motorola Chair Professor of Chemical Engineering and Vice President of International Affairs. B.S., University of Illinois, Urbana-Champaign; Ph.D., University of California, Berkeley. Research interests: Thin liquid films, foams, emulsions and nano-particle suspensions, film rheology and applications, wetting, spreading and adhesion of nano-fluids on solid surfaces, environmental technologies, food colloids.

Research Faculty

Nader Aderangi (aderangi@iit.edu), Lecturer in Chemical Engineering and Director of Undergaduate Department Laboratories. B.S., University of Tehran; M.S., University of Colorado; Ph.D., Illinois Institute of Technology. Research interests: Unit operations, chemical processes, interfacial mass transfer, rheological properties.

Alex Nikolov (nikolov@iit.edu) Research Professor of Chemical Engineering. B.S., Ph.D., University of Sofia (Bulgaria). Research interests: Interfacial rheology, foams, emulsion, dispersion, and thin liquid films.

Bert Plomp (l.plomp@ecn.nl) Research Professor of Chemical Engineering and Project Manager Supercapacitors, Energy Research Centre of the Netherlands ECN. Ing. Electrical Engineering and Information Technology, Ir. Applied Physics Delft University of Technology (Netherlands); Dr. Physical Chemistry, Free University of Amsterdam (Netherlands) Research interests: Fuel cells and supercapacitors.

J. Robert Selman (selman@iit.edu), IIT Distinguished Research Professor of Chemical Engineering. Ing., Technical University (Netherlands); M.S., University of Wisconsin-Madison; Ph.D., University of California, Berkeley. Research interests: Fuel cell and battery design and operation; high-temperature fuel cells; lithium battery design and thermal management.

Yang-Kook Sun (ysun5@iit.edu) Research Professor of Chemical Engineering. M.S., Ph.D. Seoul National University. Research interests: Lithium batteries, hybrid electrochemical capacitors with high power and high capacitor, solid oxide fuel cell.

Adjunct Faculty

Robert Anderson, Master of Management, Northwestern University.

Admission Requirements

Cumulative Undergraduate GPA: 3.0/4.0
GRE score minimum:
M.S./MAS: 900 (quantitative + verbal), 2.5 (analytical writing)
Ph.D.: 1000 (quantitative + verbal), 3.0 (analytical writing)
TOEFL minimum score: 550/213/80*

Note: The GRE requirement is waived for Professional Masters degree applicants who hold a Bachelor of Science in a related field from an ABET-accredited university in the United States, with a minimum cumulative GPA of 3.0/4.0

Certificate program applicants must possess a bachelors degree with a minimum cumulative GPA of 2.5 on a 4.0 scale. The GRE is not required.

Meeting the minimum GPA and test score requirements does not guarantee admission. Test scores and GPA are just two of several important factors considered. Admission to graduate study in chemical engineering, biological engineering, or gas engineering requires the completion of a program leading to a bachelors degree in chemical engineering or another engineering discipline from an accredited institution. Depending on the students background, additional deficiency courses, some of which may not count toward the degree, may be required. Please see the departments list of applicable undergraduate courses.

Admission to the graduate degree program in biological engineering requires one college-level semester of biology. Students not meeting this requirement may be admitted, but will have to take CHE 412 to remove the deficiency. Admission to graduate degree programs in food process engineering normally requires a bachelors degree in chemistry; biology; food science; chemical, agricultural, food or environmental engineering; or a related field. Depending on the students background, additional deficiency courses, some of which may not count toward the degree, may be required. Please see the departments list of applicable undergraduate courses.

* Paper-based test score/computer-based test score/internet-based test score.

Master of Biological Engineering

30 credit hours
No Thesis Requirement
The objective of this degree program is to prepare students for professional practice in any field of engineering involving heavy emphasis on biological processes, and to provide a foundation in the fundamental knowledge of biological engineering. The student must have a minimum grade point average of 3.0/4.0 in the core areas. Candidates are required to take a total of 30 credits, 9 credits for core courses, 7 credits of required biology courses, 2 credits of a required professional course, and 12 credits of electives chosen from the list below.

Core Courses

CHE 406 Transport Phenomena
CHE 503 Thermodynamics
CHE 577 Bioprocess Engineering

A minimum grade point average of 3.0/4.0 is required for core courses.

Biology requirement:

BIOL 504 Biochemistry Lectures
BIOL 515 Molecular Biology (after completing BIOL 504)

Professional requirement:

CHE 506 Entrepreneurship and Intellectual Property Management

Electives

BME 533 Biostatistics
BME 570 Engineering Biocompatible Materials
CHE 552 Bionanotechnology and Interfacial Phenomena
CHE 514 Process Analytical Technology
CHE 519 Biosensors
CHE 533 Statistical Analysis of Systems
CHE 545 Metabolic Engineering
CHE 573 Bioseparations
CHE 580 Biomaterials
CHE 583 Pharmaceutical Engineering
CHE 584 Tissue Engineering
BME 525 Concepts of Tissue Engineering
CHE 585 Drug Delivery
CHE 597 Research Project
ENVE 513 Biotechnological Processes in Environmental Engineering

Any 500 level Food Process Engineering course

Other approved electives from CHE, CHEM, BME, BIOL

Master of Chemical Engineering

30 credit hours
No Thesis Requirement
Project option

The objective of this degree program is to prepare students for professional practice in the field of chemical engineering, and to provide a foundation in the fundamental knowledge of chemical engineering. The student must have minimum grade point average of 3.0/4.0 in the core areas. Candidates are required to take a total of 30 credits, 12 credits for core courses, 2 credits of a required professional course, and 16 credits of electives. Elective courses are to be determined in consultation with academic advisor. The student must have minimum grade point average of 3.0/4.0 in the core areas.

Core courses:

CHE 406 Transport Phenomena
CHE 503 Thermodynamics
CHE 525 Chemical Reaction Engineering*

AND one of the following:

CHE 535 Applications of Mathematics to Engineering
CHE 530 Advanced Process Control

A minimum grade point average of 3.0/4.0 is required for core courses.

*Note: Interested students can substitute, upon advisor consent, CHE 577: Bioprocess Engineering for CHE 525: Chemical Reaction Engineering.

Professional requirement:

CHE 506 Intellectual Property Management and Entrepreneurship

Master of Food Process Engineering

32 credit hours
Professional Non-Thesis

Admission Requirements for Master of Food Process Engineering
Cumulative undergraduate GPA minimum: 3.0/4.0
GRE 950 (quantitative + verbal) and 2.5 analytical writing†
TOEFL minimum: 550/213/80*

**Paper-based test score/computer-based test score/internet-based test score.*

†The GRE requirement is waived for applicants who hold a Bachelor of Science in a related field from an ABET-accredited university in the United States, with a minimum cumulative GPA of 3.0/4.0

Program Description
The Food Process Engineering (FPE) programs at NCFST are directed toward students with a background and career objectives in engineering related disciplines. GPA and test scores are just two of the several important factors considered. Admission to graduate study in food process engineering generally requires a Bachelors degree in chemical, agricultural, food or environmental engineering; food science; chemistry; biology; or a related field. Depending on the student's background, additional proficiency courses, some of which may not count toward the degree may be required. Please see the department's list of applicable undergraduate courses. Students in the Master of Food Process Engineering program are encouraged to complete an independent project and should consult with their NCFST, IIT faculty advisor to plan a program of study best suited to their background and interests. Candidates are required to take a total of 32 credit hours, 15-18 of which must be from the core courses listed below, 8 -11 credit hours must be selected from elective courses, and 5-6 credit hours must be selected from the Chemical and Biological Engineering Department Courses. Courses are offered at NCFST and via internet with the exception of FPE 506, FPE 593, FPE 594, and FPE 597.

Core Course Requirements

FPE 505 Food Microbiology
FPE 506 Food Microbiology Laboratory*
FPE 521 Food Process Engineering
FPE 522 Advanced Food Process Engineering
FPE 524 Fundamentals of Food Science and Technology
FPE 541 Principles of Food Packaging

* FPE 506 is required unless the student has enough professional experience to allow a substitute class, the decision will be made by the NCFST Program Director.

Proficiency Requirement
These courses may be required if the student has not taken an equivalent course at the undergraduate level:

CHE 406 Transport Phenomena
CHE 423 Chemical Reaction Engineering
CHE 435 Process Control

The student must have a minimum grade point average of 3.0/4.0 in the core areas. In addition to the core courses, coursework may be selected (with NCFST advisor approval) to satisfy the needs of the individual student or may be concentrated in one of the following areas of specialization:

- Process and product development
- Food processing operations
- Food Packaging
- Food Safety
- Food Biotechnology
- Process and quality monitoring and control

Required courses for these specializations are described in the course descriptions.

FPE Electives (8-11 credit hours)
Students must take at least two courses from the following group of food process engineering courses:

FPE 504 Food Biotechnology
FPE 507 Food Analysis
FPE 511 Food Law and Regulation
FPE 520 Low-Acid Canned Food Regulations and Microbiology
FPE 523 Food Engineering Process Delivery
FPE 526 Engineering Principles of Food
FPE 531 HACCP Planning and Implementation
FPE 593 Seminar Series
FPE 594 Special Projects
FPE 597 Special Problems

Students can enroll in FPE 594 and 597 with a maximum of 6 credit hours total between both courses with NCFST Advisor approval. However, when 597 is used as short course, the total credit hours must not exceed 8 credit between 594 and 597.

Students must take at least two courses from the following group of chemical and biological engineering courses:

FPE Elective Requirements (5-6 credit hours)

CHE 426 Statistical Tools for Engineers
CHE 439 Numerical Analysis
CHE 494 Chemical Process Design
CHE 560 Statistical Quality and Process Control
CHE 573 Bioseparations
CHE 577 Bioprocess Engineering
CHE 579 Enzyme Reactor Engineering
ENVE 513 Biotechnological Processes in Wastewater Treatment
ENVE 542 Environmental Unit Processes

Student may enroll in a ChBE course elective that is not listed above, with NCFST advisor approval.

Master of Science in Chemical Engineering

32 credit hours
Thesis

The objective of this degree program is to enable the student to build a strong foundation in multiple areas of chemical engineering and to specialize in one area via research and thesis. Candidates are required to take a total of 32 credit hours, 12 credits of which must be for the chemical engineering core courses listed below, and six to eight credit hours must be in research and thesis work. Elective courses are to be determined in consultation with academic advisor.

Core Courses

CHE 525 Chemical Reaction Engineering
CHE 535 Applications of Mathematics to Engineering
CHE 551 Advanced Transport Phenomena
CHE 553 Advanced Thermodynamics

Students can enroll in a ChBE course that may not be listed with the NCFST advisor approval. A minimum grade point average of 3.0/4.0 is required for core courses. Aside from the core courses, coursework may be selected (with advisor approval) to satisfy the needs of the individual student and may be aligned with the research areas listed in the Department of Chemical and Biological Engineering section of this bulletin.

A thesis may be completed outside the department only by special arrangement with the department chair. The successful M.S. degree candidate will complete a thesis based on research as well as an oral defense of the thesis, under the direction of the thesis examining committee.

Master of Science in Computer Science/Master of Chemical Engineering

44 credit hours
No thesis requirement

The objective of the program is to educate, and prepare for professional practice, process engineers with broad based knowledge of chemical engineering and computer science fundamentals, and computer scientists with strong engineering fundamentals. Candidates are required to take 18 credit hours in graduate chemical engineering courses (courses numbered 500 or higher) and 26 credit hours in computer science courses (of which 20 credit hours must be in courses numbered 500 or higher). The 18 credit hours in chemical engineering courses consist of 12 credit hours in core courses listed in the description of the Master of Science in Chemical Engineering requirements and six credit hours from the following courses:

CHE 507 Computer-Aided Design
CHE 508 Process Design and Optimization
CHE 528 Analysis and Simulation of Chemical Processing
CHE 532 Process Modeling
CHE 533 Statistical Analysis of Systems
CHE 536 Computational Techniques in Engineering
CHE 560 Statistical Quality and Process Control

Students should refer to the Department of Computer Science section of this bulletin for details on computer science course requirements for the dual degree.

Master of Science in Food Process Engineering

32 credit hours
Thesis and Oral Defense (written thesis report required)

Admission Requirements for Master of Science in Food Process Engineering

Cumulative undergraduate GPA minimum: 3.0/4.0
GRE 1100 (quantitative + verbal) and 2.5 analytical writing
TOEFL minimum: 550/213/80*

**Paper-based test score/computer-based test score/internet-based test score.*

Program Description

The Food Process Engineering (FPE) programs at NCFST are directed toward students with a background and career objectives in engineering related disciplines. GPA and test scores are just two of the several important factors considered. Admission to graduate study in food process engineering generally requires a Bachelors degree in chemical, agricultural, food or environmental engineering; food science; chemistry; biology; or a related field. Depending on the student's background, additional proficiency courses, some of which may not count toward the degree may be required. Please see the department's list of applicable undergraduate courses. Students in the Food Process Engineering programs should consult with their NCFST, IIT faculty advisor to plan a program of study best suited to their background and interests. Students enrolled in FPE Master of Science programs must register for six to eight credit hours of research. Research work will usually be conducted at the Moffett Campus; research topics will be selected from the food safety, food process engineering, food biotechnology, or related topics.

Candidates are required to take a total of 32 credit hours, 18 of which are the required courses listed below, a minimum of 6-8 credit hours in Research and Thesis, 5-6 credit hours must be taken from Chemical and Biological Engineering Department courses, and the remaining 1-3 credit hours can be taken from FPE electives, if needed. Courses are offered at NCFST and via the internet, with the exception of FPE 506, FPE 593, FPE 594, and FPE 597.

Core Course Requirements (18 credit hours)

FPE 505	Food Microbiology
FPE 506	Food Microbiology Laboratory
FPE 521	Food Process Engineering
FPE 522	Advanced Food Process Engineering
FPE 524	Fundamentals of Food Science and Technology
FPE 541	Principles of Food Packaging

Core Research Thesis Requirements (6-8 credit hours)

FPE 591 Research and Thesis

Research for the thesis must be carried out under the direct supervision of a participating faculty member. Based on the requirements of the research project, thesis committee members may be chosen from IIT faculty members from ChBE and various departments, NCFST/FDA scientists, and the food industry scientists. The final thesis examination consists of submission of a written thesis, followed by an oral presentation open to all NCFST staff and the university community. (A thesis may be completed outside the department only by special arrangement with the department chair. The final examination is normally oral, but may be written at the discretion of the thesis examining committee.)

As a part of the thesis, the student is expected to contribute to one or more high quality peer-reviewed journal article(s). The student is also encouraged to present the research at a national professional society meeting.

Master of Science in Food Process Engineering (continued)

Proficiency Requirement

These courses may be required if the student has not taken an equivalent course at the undergraduate level:

CHE 406 Transport Phenomena (3)
CHE 423 Chemical Reaction Engineering (3)
CHE 435 Process Control (3)

The student must have a minimum grade point average of 3.0/4.0 in the core areas. In addition to the core courses, coursework may be selected (with adviser approval) to satisfy the needs of the individual student or may be concentrated in one of the following areas of specialization:

- Food Processing Operations
- Food Packaging
- Food Safety
- Food Biotechnology
- Process and Quality Monitoring and Control

Elective Requirements (5-6 credit hours)

Students must take two courses from the following group of chemical and environmental engineering courses: (5-6 credit hours)

CHE 426 Statistical Tools for Engineers
CHE 439 Numerical Analysis
CHE 494 Chemical Process Design
CHE 560 Statistical Quality and Process Control
CHE 573 Bioseparations
CHE 577 Bioprocess Engineering
CHE 579 Enzyme Reactor Engineering
ENVE 513 Biotechnological Processes in Wastewater Treatment
ENVE 542 Environmental Unit Processes

AND
FPE Electives
(1-3 credit hours)

FPE 504 Food Biotechnology
FPE 507 Food Analysis
FPE 511 Food Law and Regulation
FPE 520 Low-Acid Canned Food Regulations and Microbiology
FPE 523 Food Engineering Process Delivery
FPE 526 Engineering Principles of Food
FPE 531 HACCP Planning and Implementation
FPE 593 Seminar Series
FPE 594 Special Projects
FPE 597 Special Problems

Student may enroll in a ChBE course that is not listed above, with NCFST advisor approval.

Doctor of Philosophy

84 credit hours
Qualifying exam
Comprehensive exam
Thesis proposal
Dissertation and oral defense

The doctorate degree in chemical engineering is awarded in recognition of mastery in chemical/biological engineering and upon demonstration of an ability to make substantial creative contributions to knowledge in chemical engineering. The recipients of these degrees will be capable of a continuing effort toward advancement of knowledge and achievement in research while pursuing an academic or industrial research career. Coursework must include 15 credits of core courses.

Core Courses

CHE 551	Advanced Transport Phenomena
CHE 553	Advanced Thermodynamics
CHE 525	Chemical Reaction Engineering
CHE 535	Applications of Mathematics to Engineering
CHE 530	Advanced Process Control or CHE 536 Computational Techniques in Engineering

A minimum grade point average of 3.0/4.0 is required in the core courses. Please refer to the credit requirements section at the front of this bulletin for additional details.

Students should consult the Transfer Credits section at the front of this bulletin for rules on how many credit hours may be transferred from another institution.

Students must pass a written qualifying examination within three semesters after they have been admitted to the Ph.D. program. The exam is diagnostic in nature, and the results of the exam will determine the student's potential for success in the Ph.D. program and recommendations for a future program of study. The examination will cover 4 core areas: thermodynamics, reaction engineering and kinetics, transport phenomena, process modeling and control.

The comprehensive examination is oral and may include a written exam based on the student's performance on the qualifying exam. The exam questions will be formulated by the members of the Ph.D. examining committee. The examination will also include oral presentation and discussion by the student of a journal article selected a priori by the examining committee. The exam must be conducted within a year following completion of the qualifying exam. The Ph.D. examining committee, which may be the same as the Ph.D. thesis committee, should be suggested by the adviser and approved by the chairperson at least three weeks prior to the examination.

The thesis proposal examination, which is diagnostic in nature, should be conducted after the comprehensive exam and at least one year before the final thesis defense. The exam will be oral and will be administered by the Ph.D. thesis committee.

Doctoral research can begin after admission to the Ph.D. program. However, the major portion of the research should not be started until the comprehensive examination is passed and the thesis proposal is approved by the committee. All research must be conducted under the supervision of a full-time department faculty member and in the laboratories of the university. Off-campus research is possible with the approval of the department chairperson. The preliminary thesis draft must meet the approval of all members of the examination committee. An oral examination in defense of the thesis is given as an open university seminar. The thesis defense must meet with the approval of the examination committee; if it does not, the committee has the authority to determine whether or not to grant a re-examination.

Certifcate Programs

The department offers 8 graduate certificate programs, with one available only via the Internet. These programs provide students with post-baccalaureate knowledge of an area of specialization within chemical. Students in these programs register as certificate students.

Certificate programs typically require a set of three to four courses that must be completed in three years with a minimum GPA of 3.0/4.0. (Note: Some courses may have prerequisites.) Students who are admitted to master's degree programs may apply coursework previously taken in a certificate program toward the requirements for the master's degree.

Biological Engineering

This program provides an introduction to the field of biological engineering and its application in biological, biomedical and environmental processes. Students must complete four courses (12 credits) to receive the certificate.

Required course

CHE 577 Bioprocess Engineering

AND at least three courses from the elective courses listed under the Master of Biological Engineering.

Current Energy Issues

This program explores issues related to the establishment of sustainable energy systems including energy/environment/economics, renewable energy, batteries and fuel cells. Students must complete 3 of the following 4 courses (9 credits) to receive the certificate.

Required Courses
At least three from the following:

CHE 517 Energy Utilization Technologies and Economics
CHE 541 Renewable Energy Technologies
CHE 543 Energy, Environment and Economics
CHE 565 Electrochemical Engineering

Food Process Engineering

This program provides an introduction to the field of food engineering, with applications of chemical engineering to food manufacturing and food safety. The program requires that a set of three to four courses must be completed within three years with a minimum GPA of 3.0/4.0. Courses are offered at NCFST and via the internet, with the exception of lab courses.

Required Courses

FPE 521 Food Process Engineering
FPE 522 Advanced Food Process Engineering

AND two courses from the following group:

CHE 518 Mass-Transfer (Prerequisite: CHE 302)
CHE 560 Statistical Quality and Process Control
CHE 573 Bioseparations
CHE 577 Bioprocess Engineering
FPE 504 Food Biotechnology
FPE 505 Food Microbiology
FPE 506 Food Microbiology Laboratory
FPE 507 Food Analysis
FPE 511 Food Law and Regulation
FPE 524 Fundamentals of Food Science and Technology
FPE 531 HACCP Planning and Implementation
FPE 541 Principles of Food Packaging

Food Processing Specialist

This program provides a broad working knowledge of technical elements of thermal processing systems (with understanding of alternative technologies) to qualify at an intermediate level as a recognized Food Processing Specialist. Students must complete four courses (12 credits) to receive the certificate. Students who are admitted to master's degree programs may apply coursework previously taken in a certificate program towards the requirements for a master's degree.

Required Courses

FPE 520 Low-Acid Canned Food Regulations and Microbiology
FPE 522 Advanced Food Process Engineering
FPE 523 Food Engineering Process Delivery
FPE 526 Engineering Principles of Food

Particle Processing

This program provides an introduction to the field of particle processing, specifically in fluidization and fluid/particle systems. Fundamentals of fluid/particle system design, computational multiphase approach to gas/particle systems and advanced measurement techniques are presented. Students must complete three courses (nine credits) to receive a certificate.

Required courses
At least one of the following courses:

CHE 542 Fluidization and Fluid/Particle Flow Systems
CHE 489 Design of Fluidized Beds and Fluid/Particle Systems

AND one/two of the following courses:

CHE 587 Particle Processing and Characterization
CHE 486 Applied Particle Technology
CHE 582 Interfacial Colloidal Phenomena
CHE 586 Particle Technology

Pharmaceutical Engineering

This program develops, expands and refines skills to advance the technology of prescription drug development and manufacturing. Fundamentals of pharmaceutical engineering, drug delivery systems and regulatory issues are presented. Students must complete four courses (12 credits) to receive a certificate.

Required courses
The following three courses:

CHE 583 Pharmaceutical Engineering
CHE 585 Drug Delivery Systems
CHE 511 Regulatory Issues in Pharmaceutical Processes

AND one of the following:

CHE 514 Process Analytical Technology
CHE 560 Statistical Quality and Process Control

Polymer Science and Engineering

This program introduces fundamentals of polymerization and polymer synthesis, polymer kinetics, polymer processing and characterizations. Students must take four courses (12 credits) to receive the certificate.

Required course

CHE 470 Introduction to Polymer Science and Engineering (Prerequisite for all other courses in this certificate program.)

AND any three of the following courses:

CHEM 535 Advanced Polymer Chemistry
CHE 538 Polymerization Reaction Engineering
CHEM 542 Characterization of Polymers (Same as MMAE 579)
CHE 555 Polymer Processing (Prerequisite: CHE 406)

Process Operations Management

This program introduces methodology and tools to improve the technical management of process operations including process modeling, simulation, monitoring, control and optimization. Students must take four courses (12 credits) to receive the certificate.

Required courses
At least one course from each of the following groups:

I

CHE 426 Statistical Tools for Engineers
CHE 533 Statistical Analysis of Systems
CHE 560 Statistical Quality and Process Control
CHE 761 Statistical Design of Experiments for Process Improvement

II

CHE 435 Process Control
CHE 437 Discrete Time Systems and Computer Control
CHE 530 Advanced Process Control (Prerequisite: CHE 435, CHE 437 or equivalent)

III

CHE 431 Artificial Intelligence Applications in Engineering
CHE 508 Process Design Optimization
CHE 528 Analysis and Simulation of Chemical Processing
CHE 532 Process Modeling

Course Descriptions

Numbers in parentheses respectively indicate class, lab and credit hours. Note: Core courses are available once per year. Other courses may be offered less frequently.

Chemical Engineering

CHE 503
Thermodynamics
Laws of thermodynamics applied to chemical and biological engineering problems, properties of real fluids, phase and chemical equilibria, applications to chemical and biological process and auxiliary equipment. Core course. Prerequisites: Undergraduate course in chemical thermodynamics.
(3-0-3)

CHE 505
Fluid Properties
Prediction and correlation of physical and transport properties using equations of state, thermodynamic relationships, phase and chemical equilibrium.
(3-0-3)

CHE 506
Entrepreneurship and Intellectual Property Management
This course aims to introduce and develop a number of diversified professional skills necessary for success in an engineering research and development environment. Selected topics covered in the areas of technology entrepreneurship, opportunity assessment, creativity and innovation, project management, management of organizational change, entrepreneurial leadership, and intellectual property management. Prerequisite: Graduate standing or consent of the instructor.
(2-0-2)

CHE 507
Computer-Aided Design
Computer process simulation to develop technically and economically optimum overall process designs. Simulation framework includes unit operation computations, physical property determinations, Newton- Raphson convergence procedures and simulation language. Prerequisite: Undergraduate course in process design.
(3-0-3)

CHE 508
Process Design Optimization
Organization of the design problem and application of single and multivariable search techniques using both analytical and numerical methods. Prerequisite: Undergraduate course in process design.
(3-0-3)

CHE 509
Advanced Topics in Reactor Engineering
Selected topics based on current research interests of the instructor. Typical examples are reactor stability analysis, diffusional effects in heterogeneous catalysis, catalyst and enzyme deactivation analysis, immobilized enzyme reaction systems, liquid-liquid or gas-liquid dispersed phase reactors, biological reactors for wastewater treatment, photochemical reactors, polymerization reactors and crystallization dynamics. Prerequisite: CHE 525 or instructor approval.
(3-0-3)

CHE 510
Fluid Dynamics
Cross listed with MMAE 510 Kinematics of fluid motion. Derivation of equations of motion and Navier-Stokes equations. Exact and approximate solution techniques. Boundary layer theory. Introduction to stability and turbulence. Prerequisite: Undergraduate course in transport phenomena.
(3-0-3)

CHE 511
Regulatory Issues in Pharmaceutical Processes
Legal and scientific issues in regulating the pharmaceutical and healthcare industrial sectors. Role of regulatory agencies; FDA and the Center for Drug Evaluation and Research. Definitions and standards: laws, regulations, policies, procedures. Manufacturing pharmaceutical drugs, devices, and components in compliance with regulations. Prerequisite: Graduate standing or consent of the instructor.
(3-0-3)

CHE 512
Heat Transfer
A survey course in conduction, convection and radiation. Problems in condensation and convection are solved with the use of fundamental laws of fluid dynamics. Finite difference and algebraic solutions for unsteady-state and heat-regenerator problems are covered. Prerequisite: CHE 406.
(3-0-3)

CHE 514
Process Analytical Technology
Provides an introduction to Process Analytical Technology (PAT) as a framework to enhance process understanding and assist in the development of reliable yet efficient pharmaceutical operations. The course is divided into four sections. Definition of critical performance attributes within the context of FDA regulations. Overview of analytic measurement methods, including at/in- or on-line measurement of chemical, physical and microbiological quantities. Mathematical description of common data analysis and chemometric methods, including statistical process monitoring, multivariate analysis and parameter estimation. Design of real-time decision systems, including feedback control of operations and risk-based analysis of final product quality (real-time release). Prerequisite: BS in engineering or equivalent.
(3-0-3)

CHE 515
Natural Gas Processing
Application of engineering principles to natural gas separation processes, including multi-stage separation, solvent extraction, adsorption, membrane separation, and supercritical extraction. Design and economic analysis of various gas treating processes such as natural gas dehydration, sweetening, and LNG processes, using commercially available process simulators. Prerequisite: CHE 505.
(3-0-3)

CHE 516
Gas Transmission and Distribution
Fundamentals of the subsonic compressible flow, flow in gas transmission distribution systems, gas measurement, storage and compression. Gas/liquid two-phase flow fundamentals. Gas transmission and distribution in pipeline network using commercially available process simulators. Prerequisite: Undergraduate course in transport phenomena.
(3-0-3)

CHE 517
Gas Utilization Technologies and Economics
Gas and electric energy markets structure, costs and load profiles; Concepts, benefits, and applications of gas for power generation, and integrated energy systems for combined cooling, heating and power (CHP); Power generation technologies of engines, turbines, microturbines, and fuel cells; Thermally-activated technologies, of absorption chillers, desiccant dehumidifiers, and steam turbines; Economics; Case studies; Software tools. Prerequisite: Undergraduate course in transport phenomena.
(3-0-3)

CHE 518
Mass Transfer
Principles of diffusion, both steady and unsteady state, as applied to heat transfer, gas absorption, distillation, drying and extraction. Prerequisite: Undergraduate course in transport phenomena.
(3-0-3)

CHE 519
Biosensors
Engineering Principles used for the detection of biomolecules and cells in the context of biomedical, environmental, biochemical process applications. Immobilization of biological receptors for interfacing biomolecules with a transducer. Specific and non-specific interactions with surfaces. Transduction mechanisms for signal detection. Signal analyte and multiple analyte detection. Nanotechnology and biosensors.
(3-0-3)

CHE 520
LNG Fundamentals and Technologies
Properties and phase equilibria of Natural Gas liquid and gas mixtures at low temperatures. Thermodynamic analysis and design of natural gas liquefaction processes. Recent advances in LNG processing, storage and transportation. Prerequisites: CHE 505
(3-0-3)

CHE 522
Fundamentals of Combustion
Fundamentals of Combustion Thermodynamics of combustion. Combustion reaction kinetics. Combustion of Gaseous and vaporized fuels. Adiabatic flame temperature. Transport processes. Gas flames classification. Premixed flames. Diffusion flames. Laminar and turbulent regimes. Flame propagation. Gas fired furnace combustion. Detonation of Gaseous mixtures. Environmental issues and greenhouse effect. Environmental control technologies. Hydrogen as a fuel.
(3-0-3)

CHE 523
Fundamentals of Heterogeneous Catalysis
Fundamental principles governing heterogeneous catalysis, including chemical reaction equilibria, kinetics of gas-surface interactions and surface chemistry. Application of these fundamental principles to catalysis by metals and to acid catalysis. Discussion of several examples of reactions of technological interest. Prerequisites: Undergraduate courses in reaction engineering and thermodynamics.
(3-0-3)

CHE 524
Industrial Catalysis
A comprehensive state-of-the-art introduction to catalytic processes and catalysts used in the chemical and petroleum industries. Prerequisite: Basic background in organic, inorganic and physical chemistry.
(3-0-3)

CHE 525
Chemical Reaction Engineering
Advanced treatment of chemical kinetics and reactor systems including non-isothermal, non-ideal flow systems. Modeling of complex reactions, catalysis and heterogeneous reactor analysis. Reactor stability concepts. Core course. Prerequisite: Undergraduate courses in reaction engineering.
(3-0-3)

CHE 527
Petrochemical Systems
This course will cover descriptions and evaluations of processes designed to manufacture petrochemicals. The source, availability and characterization of feedstock will also be discussed. Process design procedures particular to petrochemicals will be emphasized. Prerequisite: Undergraduate course in process design.
(3-0-3)

CHE 528
Analysis and Simulation of Chemical Processing
Introduction to techniques for computer- aided analysis of chemical processing systems. Study of process simulation computer systems. Prerequisites: Undergraduate courses in process modeling, numeric methods and process design.
(3-0-3)

CHE 529
Advanced Process Design of Chemical Processes
In depth treatment of topics on the chemical engineering design and operation of chemical processes. Selected process applications are emphasized. Prerequisites: Undergraduate course in process design.
(3-0-3)

CHE 530
Advanced Process Control
State space, transfer function and discrete-time representations of process systems. Control system design. Interaction assessment. Multivariable and model predictivecontrol techniques. Core course for Ph.D. Prerequisite: Undergraduate course in process control.
(3-0-3)

CHE 532
Process Modeling
Development of steady-state and dynamic models of various physical and chemical processes. Parameter identification and state-estimation techniques. Prerequisite: Undergraduate course in process modeling.
(3-0-3)

CHE 533
Statistical Analysis of Systems
Multivariate probability distributions. Inference about mean, variance. Multivariate linear regression and response surface analysis. Principal components analysis, factor analysis, canonical correlation analysis. Clustering, discrimination and classification. Selected advanced topics such as survey design, design of experimental techniques, statistical methods for discrete and binary variables, time series analysis, partial least squares techniques. Prerequisites: Undergraduate course in statistics.
(3-0-3)

CHE 535
Applications of Mathematics to Chemical Engineering
Mathematical techniques and their application to the analytical and numerical solution of chemical engineering problems. The analytical component includes review of linear algebra, as well as solution of ordinary, partial differential and integral equations. The numerical component includes iterative solution of algebraic equations, numerical analysis and solution of ordinary differential equations. Core course.
(3-0-3)

CHE 536
Computational Techniques in Engineering
Advanced mathematical techniques, numerical analysis, and solution to problems in transport phenomena, thermodynamics and reaction engineering. Review of iterative solution of algebraic equations. Nonlinear initial and boundary value problems for ordinary differential equations. Formulation and numerical solution of parabolic, elliptic and hyperbolic partial differential equations. Characteristics, formulation and numerical solution of integral equations. Solution of transient two-phase flow problems using CFD codes. Prerequisite: A familiarity with FORTRAN is desirable. Core course for Ph.D.
(3-0-3)

CHE 538
Polymerization Reaction Engineering
The engineering of reactors for the manufacture of synthetic polymeric materials, commercial processes for manufacture of polymers of many types, polymer chemistry and engineering reactor design. Prerequisite: Undergraduate course in reaction engineering.
(3-0-3)

CHE 540
Flow-Through Porous Media and Fundamentals of Reservoir Engineering
Introduction to structural geology and gas and oil formation. Reservoir rock and fluid properties. Darcys Law and applications. Single and multiphase flow in porous media. Fundamentals of enhanced oil recovery. Unconventional gas and petroleum reserves.
(3-0-3)

CHE 541
Renewable Energy Technologies
Topics related to renewable energy technologies including review of renewable energy sources (solar, wind, biomass, etc.), energy storage and conversion with emphasis on batteries and fuel cells, hydrogen as an energy carrier, and the hydrogen economy.
(3-0-3)

CHE 542
Fluidization and Gas-Solids Flow Systems
Fluidization phenomena (bubbling, slugging, elutriation and jets in fluidized beds). Multiphase flow approach to fluidization and gas/solids flow systems. Kinetic theory approach to fluid/particle flow systems. Analysis of flow of particles in pneumatic conveying lines (dilute flow) and stand pipe (dense flow). Hydrodynamic analysis of spouted and circulating fluidized beds. Examples from current literature on applications of multiphase flow. Prerequisites: CHE 501, CHE 535.
(3-0-3)

CHE 543
Energy, Environment and Economics
The linkage of energy, environmental and economic issues. The impact of energy supply and end use on human well-being and the ecosystem. A comprehensive approach to the resolution of resource, technical, economic, strategic, environmental, socio- and geopolitical problems of the energy industries. Pathways to a sustainable global energy system. Same as ENVE 544.
(3-0-3)

CHE 544
Kinetic Theory of Multiphase Flow
The classical theory of gases is applied to particulate flow and to fluidization by the introduction of a granular temperature concept. Equations of state for powders, viscosities of suspensions and Navier-Stokes-like equations of motion are derived. Applications to the design of industrial equipment, such as fluidized bed catalytic crackers, are shown using solutions of these equations with workstations.
(3-0-3)

CHE 545
Metabolic Engineering
Cellular metabolism, energetics and thermodynamics of cellular metabolism, regulation of metabolic pathways, metabolic flux analysis, metabolic control analysis, analysis of metabolic networks, synthesis and manipulations of metabolic pathways, applications case studies.
(3-0-3)

CHE 551
Advanced Transport Phenomena
Formulation, solution and interpretation of problems in momentum, energy and mass transport phenomena that occur in chemical and biological processes. Prerequisite: Undergraduate course in transport phenomena.
(3-0-3)

CHE 552
Bionanotechnology and Interfacial Phenomena
Bionanotechnology and Interfacial Phenomena The course will introduce the students to the interdisciplinary concept of bionanotechnology, where engineering at atomic and molecular scale is achieved via biological principles of self-assembly and self-organization. Structural and functional principles of bionanotechnology will be discussed with an emphasis on impact of biological nanoengineering or interfacial science.
(3-0-3)

CHE 553
Advanced Thermodynamics
Advanced thermodynamics for research-oriented graduate students. The course covers the fundamental postulates of thermodynamics and introductory statistical mechanics, with applications to pure fluids, fluid mixtures, elastic solids, surfaces and macromolecules. (3-0-3) Prerequisite: Undergraduate course in chemical thermodynamics including thermodynamics of single-component systems and mixtures.
(3-0-3)

CHE 555
Polymer Processing
Analysis of momentum, heat- and mass-transfer polymer processing operations. Polymer processes considered include extrusion, calendering, fiber spinning, injection molding and mixing. Prerequisite: Undergraduate course in transport phenomena.
(3-0-3)

CHE 560
Statistical Quality and Process Control
Basic theory, methods and techniques of on-line, feedback, quality-control systems for variable and attribute characteristics. Methods for improving the parameters of the production, diagnosis and adjustment processes so that quality loss is minimized. Same as MMAE 560.
(3-0-3)

CHE 561
Chemical Engineering Calculations
Comprehensive problems to give the student a higher degree of proficiency in analyzing and solving comprehensive problems and situations. Subject matter varies with the interest and background of the instructor.
(3-0-3)

CHE 563
Separation Processes
Application of chemical engineering principles to separation processes, including distillation, extraction, chromatographic separation, electrokinetic separation, membrane separation, supercritical extraction, crystallization, foam fractionation and solubilization and coacervation. Prerequisites: Undergraduate course in transport phenomena and thermodynamics.
(3-0-3)

CHE 565
Fundamentals of Electrochemistry
Thermodynamics and potential, Marcus theory, charge transfer kinetics and mass transport of simple systems. Electrode reactions coupled with homogeneous chemical reactions. Double-layer structure and adsorbed intermediates in electrode processes. Potential step and potential sweep methods.
(3-0-3)

CHE 566
Electrochemical Engineering
Basic concepts of electrochemistry used in electrochemical reactor analysis and design. Electrolytic mass transfer, current and potential distribution, corrosion engineering. Electrodeposition. Batteries and fuel cells. Industrial electrolysis and electrosynthesis.
(3-0-3)

CHE 573
Bioseparations
Recovery of particulates (cells and other solids), chromatographic separations and applications, membrane separations, electrophoresis, recycle and immobilization, economics of bioseparations.
(3-0-3)

CHE 575
Polymer Rheology
Flow of viscoelastic fluids, integral and differential constitutive equations from continuum and molecular considerations, methods of experimental evaluations. Prerequisite: CHE 406.
(3-0-3)

CHE 576
Industrial Chemistry: Catalytic and Thermal Reactions and Processes
Includes petroleum refining, gasoline and alternative fuels, petrochemicals, such as polymers and polymer intermediates for films, fibers, elastomers and thermosets; surfactants, adhesives, lubes and gasoline additives; paper, wood, pesticides, pharmaceutical and biotechnology; sulfuric acid and derivatives, fertilizers, ceramics, glasses and other aspects of materials science.
(3-0-3)

CHE 577
Bioprocess Engineering
Application of engineering principles to the biological production processes. Enzyme kinetics, cell culture kinetics, transport phenomena in cells, membranes, and biological reactors, genetics, bioseparation and downstream processing, energetics of metabolic pathways, operation modes of cell cultures, mixed cultures and their applications.
(3-0-3)

CHE 579
Enzyme Reactor Engineering
The biochemical structure of proteins (enzymes), enzyme kinetics, methods of enzyme production and purification and methods of enzyme immobilization are discussed. Fundamentals of reactor design with emphasis on diffusional influences in heterogeneous systems are developed to permit analysis of novel immobilized enzyme processes. Prerequisite: Undergraduate course in reaction engineering.
(3-0-3)

CHE 580
Biomaterials
Metal, ceramic, and polymeric implant materials. Structure-property relationships for biomaterials. Interactions of biomaterials with tissue. Selection and design of materials for medical implants.
(3-0-3)

CHE 581
Processing and Applications of Polymer Composite Materials
Types, multiphase structures, classification, processing. Different moldings, foamed and cellular composites, cellular structure, types of foams. Applications.
(3-0-3)

CHE 582
Interfacial and Colloidal Phenomena with Applications
Applications of the basic principles of physical chemistry, surfactants and interfacial phenomena, surface and interfacial tension, adsorption of surfactants from solutions, spreading, contact angles, wetting, electrokinetic phenomena, rheology, dynamic interfacial properties, mass transport across interfaces. Applications include emulsions, foams, dispersions, tribology, detergency, flotation, enhanced oil recovery, suspension, emulsion polymerization and liquid membranes. Prerequisites: Undergraduate course in transport phenomena and thermodynamics.
(3-0-3)

CHE 583
Pharmaceutical Engineering
Application of transport phenomena, and reaction engineering to pharmaceutical processes. Heat and mass transfer in bioreactors and the fluidized beds. Drying, coating and granulation. Environmental and economical issues in the pharmaceutical processes. Examples from industrial processes and current literature.
(3-0-3)

CHE 584
Tissue Engineering
Growth and differentiation of cells and tissue. In vitro control of tissue development. In vivo synthesis of tissues and organs. Transplantation of engineered cells and tissue. Techniques and clinical applications of tissue engineering.
(3-0-3)

CHE 585
Drug Delivery
Principle of diffusion in liquid membranes and polymers, and methods for measurement and analysis of diffusion coefficient. Principle of molecular transport in polymeric material, and drug solubility in polymers. Intravenous infusion, and polymer drug delivery systems. Process involved and kinetics of solute release. Design and optimization of drug delivery systems based on pharmacokinetic/pharmacodynamic requirements.
(3-0-3)

CHE 586
Particulate Technology
Advances in applied particulate technology. Current specialized topics in systems such as powders, emulsions, suspensions, dusts and mists.
(3-0-3)

CHE 587
Particle Processing and Characterization
Particle rheology, particle size and distribution measurements, pulverization and attrition processes, agglomeration and materials processing.
(3-0-3)

CHE 591
Research and Thesis for M.S. Degree

CHE 593
Seminar in Chemical Engineering
Presentations on recent developments in the field by academic and industrial visitors.
(1-0-1)

CHE 594
Special Projects
Advanced projects involving computer simulation, modeling or laboratory work.
(Credit: 16 credit hours)

CHE 597
Special Problems
Independent study and project.
(Credit: Variable)

CHE 691
Research and Thesis for Ph.D. Degrees

CHE 701
Computer-Aided Process Design and Optimization
Process design, steady-state and dynamic process simulation and process optimization using commercial software for computer-aided process design and optimization. Prerequisites: CHE 494 or consent of instructor.
(2-0-2)

CHE 703
Computer Aided Process Modeling
Computer-aided modeling of lumped and distributed parameter systems of process models. Numerical algorithms for solving the resultant differential equations. Nonlinear parameters estimations from single and multi-response data, optimal experimental design and model discrimination.
(2-0-2)

CHE 761
Statistical Design of Experiments for Process Improvement
Full and fractional factorial designs of experiments, optimal designs, interactions, analysis of variance, empirical modeling and regression analysis, response surface analysis, process improvement by Taguchi methods and alternative designs of experiments. Prerequisite: Consent of instructor.
(2-0-2)

CHE 771
Applications of Enzymes and Microbes in Food Processing
Kinetics of enzyme-catalyzed reactions, applied enzyme catalysis in the food industry, stoichiometry of cell growth and product formation, carbon metabolism pathways, fermentation technology, applications of mixed cultures in the food industry, case studies. Prerequisite: CHE 411 or consent of instructor.
(2-0-2)

Food Process Engineering

FPE 504
Food Biotechnology
Introduction of biotechnology in the food industry including genetic engineering of microorganisms. Fundamentals of microbial genomics and proteomics. Practice of a variety of software and bioinformatics tools including database search, sequence alignment, phylogenetic and cluster analyses, gene prediction, genomic map construction, structural and functional prediction of proteins. Applications of DNA fingerprinting techniques in food safety and public health. Prerequisite: Biology or Microbiology.
(3-0-3)

FPE 505
Food Microbiology
Microorganisms of importance to food safety, spoilage and food fermentations. Principles of occurrence and control. Importance of sanitation and prevention of public health problems. Microbiological contaminants and methods for their detection. Mechanisms of microbial inactivation. Prerequisites: Introductory Microbiology, Food Science and Biochemistry
(3-0-3)

FPE 506
Food Microbiological Laboratory
Basic microbiological techniques and safe laboratory practices. Introductory Food Microbiology. Isolation of pathogenic bacteria. Spoilage microorganisms. Fermentation. Environmental Monitoring. Rapid Identification tests. Sporeformers. Prerequisites: Introductory Microbiology and Biochemistry
(3-0-3)

FPE 507
Food Analysis
Techniques for analyzing food toxins, food constituents of public health concern, intentional and unintentional food additives, modern separation and analytical techniques. Prerequisites: chemistry, analytical chemistry.
(3-0-3)

FPE 511
Food Law and Regulation
Legal and scientific issues in regulating the nations food supply and nutritional status. Rules of regulatory agencies; Federal Food, Drug and Cosmetic Act; definitions and standards for food and adulterated foods. Manufacturing processed foods in compliance with regulations.
(3-0-3)

FPE 520
Low-Acid Canned Food Regulations and Microbiology
Regulatory requirements for the U.S. Food and Drug Administration, and the broad microbial issues associated with low acid canned food (LACF) products. Topics will include the U.S. Food Drug & Cosmetic (FD&C) Act, Emergency Permit Control, 21 Code of Federal Register (CFR) parts 108, 113, and 114, record requirements, sources of microbial contamination, characteristics of Clostridium botulinum, mesophilic spore formers, indicator organisms, and introduction to microbial heat resistance. Prequisite: Consent of instructor.
(3-0-3)

FPE 521
Food Process Engineering
Food engineering fundamentals, heat transfer in food processing, food rheology, freezing of foods, food dehydration, kinetics of chemical reactions in foods, refrigeration and thermal process calculations, alternative methods of food processing.
(3-0-3)

FPE 522
Advanced Food Process Engineering
Process calculations for food processing methods such as canning, aseptic processing, ohmic heating, microwave processing and pulsed energy processing. Extrusion techniques in food processing. Discussion of new food processing techniques and safety implications. Prerequisite: FST 521 or permission of the instructor.
(3-0-3)

FPE 523
Food Engineering Process Delivery
Requirements for the U.S. Food and Drug Administration food canning regulations, including system design, process establishment, operation, and inspection records. Operations and calibration requirements of thermal processing equipment. Process design, documentation of process deviation and calculation of process delivery. Prequisite: Consent of instructor.
(3-0-3)

FPE 524
Fundamentals of Food Science and Technology
This course will cover the central food science issues encountered with storage and processing of all major American food commodities including meats, grains, confections, vegetables, eggs, dairy. It will also review the relevant chemistry, physics and engineering required to understand common food-related unit operations such as drying, freezing, sterilization and radiation treatment of foods. An introduction to microbial and chemical issues of food quality and safety will also be covered.
(3-0-3)

FPE 526
Engineering Principles of Food
Methods for conducting seal integrity examinations, spoilage diagnosis, and traceability, defining and classifying package defects. Types of packaging materials, including metal, glass, plastics, flexible and composite containers, and their closure and sealing systems. Aseptic and alternative process delivery systems. Prequisite: Consent of instructor.
(3-0-3)

FPE 531
HACCP Planning and Implementation
Examination of the hazard analysis and critical control point (HACCP) principles; microbiological and process overviews; generic HACCP models, good manufacturing practices; monitoring of critical control points, process control and implementation.
(3-0-3)

FPE 541
Principles of Food Packaging
Type and application of packaging materials. Migration Theories. Food Package interaction. Package testing to ensure safety. Special design considerations. Recycling of package materials.
(3-0-3)

FPE 591
Research and Thesis
Students conduct their research on a particular topic and write a thesis. Students are also required to write manuscripts from his/her thesis work for publication. Prequisite: Consent of instructor.
(Credit: 6-8 hours)

FPE 593
Seminar on Food Safety and Technology
Students attend seminars offered during the semester. Each student is also required to give a 30 minute presentation on a topic of his/her interest or a research project on which she/he has worked.
(Credit : 1 hour)

FPE 594
Special Projects
Advanced projects involving analysis of food safety processing, packaging and biotechnology systems. Prequisite: NCFST advisor approval.
(Credit: 1-6 hours)

FPE 597
Special Problems
Independent study focusing on current problems, issues of professional relevance. Topics selected from food process engineering, food safety, packaging, biotechnology. Repeatable to a maximum of six credit hours. Prequisite: NCFST advisor approval.
(Credit: 1-6 hours)

Undergraduate Courses Available to Graduate Students

With the approval of their advisors, students in the chemical and biological graduate programs may apply up to 12 credits hours to their program from 400-level undergraduate courses. This does not apply to students pursuing the dual masters degree in chemical engineering and computer science.