

# CHEMICAL ENGINEERING AND MATERIALS SCIENCE

Office: 1100 W. Engineering Building; 313-577-3800

Chairperson: Jeffrey Potoff

<http://engineering.wayne.edu/che/>

## Chemical Engineering

The field of chemical engineering embraces those industries in which matter is treated to effect a change of state, energy content, or composition, and in which chemical engineers may be concerned with either the processes or the process equipment used for them. Examples of such industries are: fuels and petroleum processing; heavy, fine and pharmaceutical chemicals; textiles and fibers; food processing and products; natural and synthetic rubbers and plastics; explosives, pulp and paper; surface coatings; disposal of chemical plant wastes; atomic energy processes; environmental control and medical systems; and the general fields of biotechnology.

Areas of specialized research and support for graduate students include thermodynamics and transport properties of polymer solutions and melts, processing, rheology and separations of polymers, heterogeneous catalysis, surface science of catalytic and polymeric materials, environmental transport and management of hazardous waste, process design, control, and manufacturing based on sustainability principles, renewable energy, biocatalysis in multiphase systems, bioremediation for waste treatment, tissue engineering, and pharmacokinetics.

## Materials Science and Engineering

Materials problems constitute an important area of research and development in the complex technology of our industrial society. The use of advanced materials, such as thermoplastic and thermoset polymers, intermetallic alloys, reinforced plastic or metal composites, ceramics and electronic materials, in the manufacturing of durable goods and devices has presented challenges to the profession of materials science and engineering. Materials engineers must understand the behavior of advanced materials, their chemical, mechanical, optical, thermal, and electrical properties, and the atomic or molecular structure that determines these properties. They can then apply their knowledge to the synthesis and processing of materials into useful products by controlling and improving their properties.

Areas of specialized research and support for graduate students include processing and rheology of polymers, thermodynamics and transport properties of polymer solutions and melts, computer simulation of polymeric and microporous materials, deformation and fracture of materials at elevated temperatures, effects of processing on mechanical properties of intermetallic alloys, influences of microstructure on fatigue, fracture toughness, stress cracking and corrosion in metals, nondestructive mechanical testing of composites, surface science of catalytic and polymeric materials, electronic materials and sensors for automotive applications.

ALBAUGH, ALEX: Ph.D., University of California-Berkeley; B.S.E, University of Michigan; Assistant Professor

CAO, ZHIQIANG: Ph.D., University of Washington; M.Eng., B.Eng., Tianjin University; Professor

DENG, DA: Ph.D., BEng, National University of Singapore; Associate Professor

DURAND, HELEN: Ph.D., M.S., B.S., UCLA; Assistant Professor

HARRIS, CAROLYN: Ph.D., University of Utah, B.S., Purdue University; Associate Professor

HUANG, YINLUN: Ph.D., M.S., Kansas State University; B.S., Zhejiang University; Professor

LIU, HAIPENG: Ph.D., Purdue; M.S., Huazhong University of Science and Technology; Associate Professor

MANKE, CHARLES W.: M.S., Ph.D., University of California at Berkeley; B.S., Oregon State University; Professor

MATTHEW, HOWARD: Ph.D., M.S., Wayne State University; B.S., University of the West Indies; Professor

NG, SIMON: Ph.D., M.S., B.S., University of Michigan; Professor

POTOFF, JEFFREY: Ph.D. Cornell University; B.S. Michigan State University; Professor and Chair

ROTHER, ERHARD W.: Ph.D., M.S., B.S., University of Michigan; Professor Emeritus

SHREVE, GINA: Ph.D., M.S., University of Michigan; B.S., Michigan State University; Associate Professor

YINGXI, ELAINE ZHU: Ph.D., University of Illinois at Urbana-Champaign; B.S., Tsinghua University; Professor

- Chemical Engineering (M.S.) (<http://bulletins.wayne.edu/graduate/college-engineering/chemical-engineering-materials-science/chemical-engineering-ms/>)
- Materials Science and Engineering (M.S.) (<http://bulletins.wayne.edu/graduate/college-engineering/chemical-engineering-materials-science/materials-science-engineering-ms/>)
- Chemical Engineering (Ph.D.) (<http://bulletins.wayne.edu/graduate/college-engineering/chemical-engineering-materials-science/chemical-engineering-phd/>)
- Materials Science and Engineering (Ph.D.) (<http://bulletins.wayne.edu/graduate/college-engineering/chemical-engineering-materials-science/materials-science-engineering-phd/>)
- Polymer Engineering Graduate Certificate (<http://bulletins.wayne.edu/graduate/college-engineering/chemical-engineering-materials-science/polymer-engineering-graduate-certificate/>)

## Chemical Engineering

### CHE 5050 Statistics and Design of Experiments Cr. 3

Application of modern statistical experimental design methods to improve effectiveness and success in experimental projects, in chemical industry manufacturing, and research and design. Offered Intermittently.

**Prerequisites:** BE 2100 with a minimum grade of C-, BE 1600 with a minimum grade of C-, (CHE 3200 with a minimum grade of C- or CHE 3600 with a minimum grade of C-), and CHE 3300 with a minimum grade of C-

**CHE 5060 Low-Cost Microfluidic and Millifluidic Systems: Design, Fabrication and Testing Cr. 3**

This course provides a hands-on, experimental introduction to the field of microfluidic and millifluidic devices. These devices are increasingly used for research, diagnostics, and treatment in cost-sensitive applications and low-resource settings. The content and methods focus on systems of interest for micro-scale biological/chemical processes and lab-on-chip applications. Project building methods employ readily available, low-cost materials and technologies, including 3D printing, polymer casting, and paper-based fluidics. The course consists of several hands-on design and build projects. Each project highlights a fabrication method and/or an analytical or processing objective. Participants work in groups to design, build and subsequently analyze the performance of functional systems using quantitative tools including: cell phone spectroscopy, electrical detection, quantitative image analysis. Not available for graduate credit. Offered Winter.

**Restriction(s):** Enrollment limited to students with a class of Senior; enrollment is limited to students with a major in Biomedical Engineering, Biomedical Engg Honors, Chemical Engineering Honors or Chemical Engineering; enrollment is limited to Undergraduate level students.

**Fees:** \$50

**CHE 5100 Quantitative Physiology Cr. 4**

Basic principles of human physiology presented from the engineering perspective. Bodily functions, their regulation and control discussed in quantitative terms and illustrated by mathematical models where feasible. Offered Every Term.

**Equivalent:** BME 5010, ECE 5100, ME 5100

**CHE 5110 Fundamental Fuel Cell Systems Cr. 4**

Introduce various types of fuel cells, materials properties of electrodes and polymeric membranes, and electrochemical mechanisms. Reforming of various types of hydrocarbon fuel to hydrogen, and reforming technology. Offered Fall.

**Equivalent:** AET 5110, EVE 5130, ME 5110

**CHE 5120 Fundamentals of Battery Systems for Electric and Hybrid Vehicles Cr. 4**

Fundamental electrochemistry and engineering aspects for electric propulsion batteries, including lead acid, nickel metal hydride, and lithium ion technologies. Offered Intermittently.

**Equivalent:** AET 5310, EVE 5120, ME 5215

**CHE 5350 Polymer Science Cr. 3**

Fundamental relationships between chemical structure and physical properties of high polymers. Basic structures, states and transitions of polymers. Polymerization reactions and processes. Molecular weight, viscous flow and mechanical properties of polymers. Offered Fall.

**Prerequisites:** MAT 2150 with a minimum grade of C- (may be taken concurrently)

**Fees:** \$10

**Equivalent:** MSE 5350

**CHE 5360 Polymer Processing Cr. 3**

A detailed analysis of polymer processing. Rheology of polymers, flow in tubes, calendaring, extrusion, coating and injection molding. Offered Intermittently.

**Prerequisites:** CHE 3200 with a minimum grade of C-

**Fees:** \$10

**Equivalent:** MSE 5360

**CHE 5811 Research Preparation II Cr. 1**

Preparation for Senior Research Project, CHE 6810. Offered Every Term.

**Prerequisites:** CHE 3200 with a minimum grade of C- and CHE 3300 with a minimum grade of C-

**CHE 5995 Special Topics in Chemical Engineering I Cr. 1-4**

A consideration of special subject matter in chemical engineering. Topics to be announced in Schedule of Classes. Offered Every Term.

**Repeatable for 8 Credits**

**CHE 5996 Chemical Engineering Research Cr. 1-6**

Research project. Offered Every Term.

**Restriction(s):** Enrollment limited to students in the following programs: BS in Chemical Engineering, BS in Civil Engineering, BS in Electrical Engineering, BS in Industrial Engineering, BS in Mechanical Engineering; enrollment limited to students in the College of Engineering.

**CHE 6100 Introduction to Sustainable Engineering Cr. 3**

Economic, environmental, social, and technological perspectives relevant to the design, operation and management of engineering activities. Multiple perspectives addressed from a system sustainability view point. Offered Yearly.

**CHE 6450 Biochemical Engineering Cr. 3**

An introductory study of the principles of chemical engineering, biochemistry and biology which are essential for the design of industrial systems involving biological transformations. Offered Intermittently.

**Prerequisites:** CHE 3400 with a minimum grade of C- or CHE 3800 with a minimum grade of C-

**CHE 6570 Safety in the Chemical Process Industry Cr. 3**

Fundamental and practical experience necessary for safe operation of a chemical process plant. Actual industrial case studies conducted under industry supervision. Offered Winter.

**Prerequisites:** CHE 3400 with a minimum grade of C- or CHE 3800 with a minimum grade of C-

**CHE 6810 Chemical Engineering Research Project Cr. 4**

**Satisfies General Education Requirement:** Writing Intensive Competency Application of engineering and science background to the completion of a senior research project. Methods of research and analysis and interpretation of data. Preparation of a written research paper; oral presentation of research results. Offered Intermittently.

**Prerequisite:** CHE 4200 with a minimum grade of C- and CHE 4600 with a minimum grade of C-

**CHE 7060 Low-Cost Microfluidic Systems: Design, Fabrication, and Computational Analysis Cr. 3**

This course provides a hands-on, experimental introduction to the field of microfluidic and millifluidic devices. These devices are used for research, diagnostics, and treatment in cost-sensitive applications and low-resource settings. The content and methods focus on systems of interest for micro-scale biological/chemical processes and lab-on-chip applications. Project building methods employ readily available, low-cost materials and technologies, including 3D printing, polymer casting, and paper-based fluidics. The course consists of several hands-on design and build projects. Each project highlights a fabrication method and/or an analytical or processing objective. Participants will design and build functional fluidic systems and will analyze/optimize system performance of using computational fluid dynamic (CFD) tools. Not available for credit after CHE 5060. Offered Winter.

**Restriction(s):** Enrollment is limited to Graduate level students; enrollment limited to students in the College of Engineering.

**Fees:** \$50

**CHE 7090 Writing for Engineering Research Cr. 3**

Provides an introduction to the basic principles of technical writing for career pursuit in an academic or industry setting, with a focus on professional manuscript and grant writing. Throughout the course, key principles examined will include the writing process, writing structure, making your writing clear and concise, and handling style, tone, and voice. Through assignments and lecture-based learning, students will examine the "dos" and the "don'ts" in preparing manuscripts for journal submission, abstracts, conference papers, letters to editors, and grants. Throughout the semester, students will receive faculty and peer critiques of their manuscript writing. Finally, students will create a foundation/government grant, with preference toward the research area of the faculty in which they work. Offered Yearly.

**Restriction(s):** Enrollment is limited to Graduate level students.

**CHE 7100 Advanced Engineering Mathematics Cr. 3**

Presentation, evaluation and use of mathematical methods within the framework of engineering problems; including ordinary and partial differential equations, transforms and vector operations. Offered Fall.

**Restriction(s):** Enrollment is limited to Graduate level students.

**Equivalent:** MSE 7100

**CHE 7200 Advanced Transport Phenomena Cr. 3**

Basic properties of heat, mass and momentum transfer systems; fundamental equations, transforms and vector operations; includes independent study project. Offered Winter.

**Prerequisite:** CHE 7100 with a minimum grade of B-

**Restriction(s):** Enrollment is limited to Graduate level students.

**CHE 7300 Advanced Thermodynamics Cr. 3**

Advanced presentation of the principles of thermodynamics; application to open systems, phase diagrams and chemical equilibria. Offered Fall.

**Restriction(s):** Enrollment is limited to Graduate level students.

**Equivalent:** MSE 7300

**CHE 7350 Polymer Solutions Cr. 3**

Solubility of polymers, configuration of chain molecules, colligative properties of dilute polymer solutions, spectroscopy, optical activity, light and x-ray scattering of polymer solutions, frictional properties of dissolved polymers, solution properties of polyelectrolytes. Offered Every Other Year.

**Prerequisite:** CHE 5350 with a minimum grade of C

**Restriction(s):** Enrollment is limited to Graduate level students.

**CHE 7390 Tissue Engineering and Hybrid Systems Cr. 4**

Seminar and project based approach to the design, development, analysis and application of organ and tissue replacement systems which incorporate processed materials and living cells. Offered Every Other Year.

**Prerequisites:** BME 5370 with a minimum grade of C and (BME 5020 with a minimum grade of C or CHE 7100 with a minimum grade of C)

**Restriction(s):** Enrollment is limited to Graduate level students.

**Equivalent:** BME 7390

**CHE 7400 Advanced Kinetics and Reactor Design Cr. 3**

Basic properties of reacting systems including the steady state approximation, the relationship of thermodynamics to kinetics, the treatment of coupled reaction problems and design of chemical reactors; includes independent study project. Offered Winter.

**Restriction(s):** Enrollment is limited to Graduate level students.

**Fees:** \$10

**CHE 7507 Machine Learning for the Chemical Sciences Cr. 3**

Presentation of the principles and methods of basic machine learning and introduction to advanced techniques with applications to chemical engineering, materials science, and chemistry with real-world data sets. Foundations of machine learning, including linear algebra, statistics, optimization, and programming. Derivation and application of machine learning principles, including regression, bias-variance trade-off, classification, and dimensionality reduction. Exploration of advanced machine learning techniques, including decision trees, random forests, support vector machines, and neural networks. Requires an independent study project using machine learning techniques to analyze and predict real-world data. Offered Winter.

**Restriction(s):** Enrollment is limited to Graduate level students.

**CHE 7530 Materials Characterization and Computational Data Analysis for Engineers Cr. 3**

Principles of data acquisition and analysis from a wide range of experimental measurements, with an emphasis on high-throughput and automated processing, data visualization, and effective communication. Data management and functional Python skills (no prior programming experience needed, though students with concerns should reach out to the instructor early). Experimental techniques covered in lessons and examples include microscopies, spectroscopies, thermal characterization, ellipsometry, rheology, and X-ray and neutron scattering and reflectivity. Offered Fall.

**Restriction(s):** Enrollment is limited to Graduate level students.

**CHE 7990 Directed Study Cr. 1-9**

Library investigation of an approved project in chemical engineering. Independent study, conferences with supervisor and preparation of a comprehensive written and oral report. Offered Every Term.

**Restriction(s):** Enrollment is limited to Graduate level students.

**CHE 8510 Graduate Co-op Experience Cr. 1-3**

Presentation of oral and written reports to peer group describing co-op experience. Offered Every Term.

**Restriction(s):** Enrollment is limited to Graduate level students.

**CHE 8996 Research Cr. 1-9**

Library and laboratory investigation of an approved proposal for advanced research project. Conferences and periodic oral progress reports. Comprehensive report of entire project upon completion. Offered Every Term.

**Restriction(s):** Enrollment is limited to Graduate level students.

**Repeatable for 30 Credits**

**CHE 8997 Chemical Engineering Graduate Seminar Cr. 0.5**

Advanced concepts in chemical engineering; presentation of research results. Must attend and present evidence of attending 30 hours of seminar over two-year period, and present one seminar. Offered Every Term.

**Prerequisite:** CHE 7200 with a minimum grade of C and CHE 7400 with a minimum grade of C

**Restriction(s):** Enrollment is limited to Graduate level students.

**CHE 8999 Master's Thesis Research and Direction Cr. 1-8**

Offered Every Term.

**Restriction(s):** Enrollment limited to students with a class of Candidate Masters; enrollment is limited to Graduate level students.

**Repeatable for 8 Credits**

**CHE 9990 Pre-Doctoral Candidacy Research Cr. 1-8**

Research in preparation for doctoral dissertation. Offered Every Term.

**Restriction(s):** Enrollment is limited to Graduate level students.

**Repeatable for 12 Credits**

**CHE 9991 Doctoral Candidate Status I: Dissertation Research and Direction Cr. 3-9**

Offered Every Term.

**Restriction(s):** Enrollment is limited to Graduate level students.

**Repeatable for 9 Credits**

**CHE 9992 Doctoral Candidate Status II: Dissertation Research and Direction Cr. 1-18**

Offered Every Term.

**Prerequisite:** CHE 9991 with a minimum grade of S

**Restriction(s):** Enrollment is limited to Graduate level students.

**Repeatable for 18 Credits**

**CHE 9993 Doctoral Candidate Status III: Dissertation Research and Direction Cr. 7.5**

Offered Every Term.

**Prerequisite:** CHE 9992 with a minimum grade of S

**Restriction(s):** Enrollment is limited to Graduate level students.

**CHE 9994 Doctoral Candidate Status IV: Dissertation Research and Direction Cr. 7.5**

Offered Every Term.

**Prerequisite:** CHE 9993 with a minimum grade of S

**Restriction(s):** Enrollment is limited to Graduate level students.

**CHE 9995 Candidate Maintenance Status: Doctoral Dissertation Research and Direction Cr. 0**

Offered Every Term.

**Restriction(s):** Enrollment is limited to Graduate level students.

**Fees:** \$434.8

**Repeatable for 0 Credits**

## Materials Science and Engineering

**MSE 5350 Polymer Science Cr. 3**

Fundamental relationships between chemical structure and physical properties of high polymers. Basic structures, states and transitions of polymers. Polymerization reactions and processes. Molecular weight, viscous flow and mechanical properties of polymers. Offered Fall.

**Prerequisites:** MAT 2150 with a minimum grade of C- (may be taken concurrently)

**Fees:** \$10

**Equivalent:** CHE 5350

**MSE 5360 Polymer Processing Cr. 3**

A detailed analysis of polymer processing. Rheology of polymers, flow in tubes, calendaring, extrusion, coating and injection molding. Offered Intermittently.

**Prerequisites:** CHE 3200 with a minimum grade of C-

**Fees:** \$10

**Equivalent:** CHE 5360

**MSE 5385 Biocompatibility Cr. 4**

Introduces concepts and applications of biocompatibility. Cellular response to implants (e.g. prosthetics, gene therapies, cells, etc.) will be covered in detail, including wound healing, immune response, and foreign body response. Topics include stem cell effects; in vitro and in vivo studies; and synthetic and natural material body response. The course material will be applicable to implant design, gene therapies, and stem cell treatments. Offered Winter.

**Prerequisites:** BIO 1050 with a minimum grade of C-, BIO 1500 with a minimum grade of C-, or BIO 1510 with a minimum grade of C-

**Equivalent:** BME 5380

**MSE 5650 Surface Science Cr. 3**

An introduction to the science and technology of surface phenomena, including surface structure, surface energy, surface diffusion, crystal growth and selected applications of technological importance. Offered Intermittently.

**Prerequisites:** BE 1300 with a minimum grade of D- and CHM 5440 with a minimum grade of D-

**MSE 7100 Advanced Engineering Mathematics Cr. 3**

Presentation, evaluation and use of mathematical methods within the framework of engineering problems; including ordinary and partial differential equations, transforms and vector operations. Offered Fall.

**Restriction(s):** Enrollment is limited to Graduate level students.

**Equivalent:** CHE 7100

**MSE 7180 Advanced Topics in Biomaterials and Tissue Biomechanics Cr. 4**

Seminar format: advanced topics presented to the class; lectures by the instructor and by the participants based on literature reviews. Topics determined by student interest. Offered Every Other Fall.

**Prerequisite:** BME 5210 with a minimum grade of C or BME 5370 with a minimum grade of C

**Restriction(s):** Enrollment is limited to Graduate level students.

**Equivalent:** BME 7300, ME 7180

**MSE 7300 Advanced Thermodynamics Cr. 3**

Advanced presentation of the principles of thermodynamics; application to open systems, phase diagrams and chemical equilibria. Offered Fall.

**Restriction(s):** Enrollment is limited to Graduate level students.

**Equivalent:** CHE 7300

**MSE 7400 Mechanical Behavior of Materials Cr. 3**

Analysis of elastic and plastic deformation of single crystals and polycrystalline materials, emphasizing the relations between metallurgical microstructure and material properties. Offered Intermittently.

**Restriction(s):** Enrollment is limited to Graduate level students.

**MSE 7990 Directed Study Cr. 1-6**

Library investigation of an approved project in materials science and engineering. Independent study, conferences with supervisor and preparation of a comprehensive report. Offered Every Term.

**Restriction(s):** Enrollment is limited to Graduate level students.

**MSE 7995 Special Topics in Materials Science II Cr. 1-4**

A consideration of special subject matter in materials science. Topics to be announced in Schedule of Classes. Offered Intermittently.

**Restriction(s):** Enrollment is limited to Graduate level students.

**Repeatable for 12 Credits**

**MSE 8996 Research Cr. 1-10**

Library and laboratory investigation of an approved proposal for advanced research project. Conferences and periodic oral progress reports. Comprehensive report of entire project upon completion. Offered Every Term.

**Restriction(s):** Enrollment is limited to Graduate level students.

**MSE 8997 Seminar Cr. 0.5**

Offered Fall, Winter.

**Restriction(s):** Enrollment is limited to Graduate level students.

**MSE 8999 Master's Thesis Research and Direction Cr. 1-8**

Offered Every Term.

**Restriction(s):** Enrollment limited to students with a class of Candidate Masters; enrollment is limited to Graduate level students.

**Repeatable for 8 Credits**

**MSE 9990 Pre-Doctoral Candidacy Research Cr. 1-8**

Research in preparation for doctoral dissertation. Offered Every Term.

**Restriction(s):** Enrollment is limited to Graduate level students.

**Repeatable for 12 Credits**

**MSE 9991 Doctoral Candidate Status I: Dissertation Research and Direction Cr. 3-9**

Offered Every Term.

**Restriction(s):** Enrollment is limited to Graduate level students.

**Repeatable for 9 Credits**

**MSE 9992 Doctoral Candidate Status II: Dissertation Research and Direction Cr. 1-18**

Offered Every Term.

**Prerequisite:** MSE 9991 with a minimum grade of S

**Restriction(s):** Enrollment is limited to Graduate level students.

**Repeatable for 18 Credits**

**MSE 9993 Doctoral Candidate Status III: Dissertation Research and Direction Cr. 7.5**

Offered Every Term.

**Prerequisite:** MSE 9992 with a minimum grade of S

**Restriction(s):** Enrollment is limited to Graduate level students.

**MSE 9994 Doctoral Candidate Status IV: Dissertation Research and Direction Cr. 7.5**

Offered Every Term.

**Prerequisite:** MSE 9993 with a minimum grade of S

**Restriction(s):** Enrollment is limited to Graduate level students.

**MSE 9995 Candidate Maintenance Status: Doctoral Dissertation Research and Direction Cr. 0**

Offered Every Term.

**Restriction(s):** Enrollment is limited to Graduate level students.

**Fees:** \$434.8

**Repeatable for 0 Credits**