# CHEMICAL AND MATERIALS ENGINEERING

Major:

- Bachelor of Chemical Engineering (p. 1)

Concentration:

- Energy Systems-Chemical (p. 2)

Minors:

- Bioengineering (p. 3)
- Chemical Processing (p. 3)
- Composite Materials Engineering (p. 3)
- Energy Production Engineering (p. 4)
- Materials Engineering (p. 4)
- Polymer Materials (p. 4)

The Chemical and Materials Engineering Department offers an undergraduate program leading to a Bachelor of Chemical Engineering degree. Chemical engineering applies the principles of the physical sciences, economics, and human relations to research, design, build, and supervise facilities that convert raw materials into useful products and services.

The majority of chemical engineers are involved in the chemical process industries that produce many of the materials and items needed in everyday life. These include medicine, food, fertilizers, plastics, synthetic fibers, petroleum, petrochemicals, ceramics, and pulp and paper products. A chemical engineer may pursue a professional career in many other fields, such as energy conversion, pollution control, medical research, and materials development in aerospace and electronic industries. Chemical engineers are employed in research, development, design, production, sales, consulting, and management positions. They are also found in government and academia. Many use a chemical engineering education as a pathway to law, medicine, or corporate management.

The curriculum in chemical engineering serves as basic training for positions in these diverse areas of the manufacturing industry or for graduate study leading to advanced degrees. The first part of the chemical engineering curriculum provides a firm foundation in mathematics, physics, and chemistry. The chemistry background is stressed. The second part of the curriculum offers a balance between classroom and laboratory experience in stressing chemical engineering topics such as transport phenomena, thermodynamics, kinetics and reactor design, separation processes, fluid flow and heat transfer operations, process control, and process design. The development of design tools, communication, and interpersonal skills is integrated throughout the curriculum. The curriculum allows minors in emerging technologies such as bioengineering, environmental engineering, and materials engineering. Those interested in attending medical/dental school can pursue a premed preparation as part of their curriculum.

The educational objectives of chemical engineering program graduates:

- have successful careers in the chemical process industry with the skills necessary to have opportunities to work in non-traditional industries and positions
- be successful at prestigious graduate, medical, and law schools
- be committed to performing ethically while serving their professions, companies, and communities
- exhibit strong critical thinking skills from the breadth of their general education and the depth of their foundation in engineering principles, and engage in continuous intellectual and personal growth

**Faculty**
Charles E. Browning, Department Chairperson
Michael Elsass, Chemical Engineering Director
Professors Emeriti: Eylon, Flach, Lu, Snide
Professors: Browning, Lafdi, Lee, Myers, T. Saliba, Sandhu, Wilkens
Associate Professor: D. Comfort
Assistant Professors: K. Comfort, Vasquez
Senior Lecturer: Ciric
Lecturer: Elsass

## Bachelor of Chemical Engineering (CME) minimum 137 hours

| | | |
|---|---|---|
| **Common Academic Program (CAP)** [1] | | |
| First-Year Humanities Commons [2] | | 12 cr. hrs. |
| HST 103 | The West & the World | |
| REL 103 | Introduction to Religious and Theological Studies | |
| PHL 103 | Introduction to Philosophy | |
| ENG 100 | Writing Seminar I [3] | |
| Second-Year Writing Seminar [4] | | 0-3 cr. hrs. |
| ENG 200 | Writing Seminar II | |
| Oral Communication | | 3 cr. hrs. |
| CMM 100 | Principles of Oral Communication | |
| Mathematics | | 3 cr. hrs. |
| Social Science | | 3 cr. hrs. |
| SSC 200 | Social Science Integrated | |
| Arts | | 3 cr. hrs. |
| Natural Sciences [5] | | 7 cr. hrs. |
| Crossing Boundaries | | up to 12 cr. hrs. |
| Faith Traditions | | |
| Practical Ethical Action | | |
| Inquiry | | |
| Integrative | | |
| Advanced Study | | |

| | |
|---|---|
| Philosophy and/or Religious Studies (6 cr. hrs.) | |
| Historical Studies (3 cr. hrs.) [6] | |
| Diversity and Social Justice [7] | 3 cr. hrs. |
| Major Capstone [8] | 0-6 cr. hrs. |

1. The credit hours listed reflect what is needed to complete each CAP component. However, they should not be viewed as a cumulative addition to a student's degree requirements because many CAP courses are designed to satisfy more than one CAP component (e.g., Crossing Boundaries and Advanced Studies) and may also satisfy requirements in the student's major.
2. May be completed with ASI 110 and ASI 120 through the Core Program.
3. May be completed with ENG 100A and ENG 100B, by placement.
4. May be completed with ENG 114 or ENG 198 or ASI 120.
5. Must include two different disciplines and at least one accompanying lab.
6. U.S. History AP credit will not satisfy this requirement.
7. May not double count with First-Year Humanities Commons, Second-Year Writing, Oral Communication, Social Science, Arts, or Natural Sciences CAP components, but may double count with courses taken to satisfy other CAP components and/or courses taken in the student's major.
8. The course or experience is designed by faculty in each major; it may, or may not, be assigned credit hours.

**Major Requirements**

| | | |
|---|---|---|
| CHM 123 | General Chemistry | 3 |
| CHM 123L | General Chemistry Laboratory | 1 |
| CHM 124 | General Chemistry | |
| CHM 124L | General Chemistry Laboratory | 1 |
| CHM 313 | Organic Chemistry | |
| CHM 313L | Organic Chemistry Laboratory | |
| CHM 314 | Organic Chemistry | |
| CHM 314L | Organic Chemistry Laboratory | |
| CME 101 | Introduction to Chemical Engineering | 0-1 |
| CME 200 | Professional Development Seminar | 0-1 |
| or COP 200 | Introduction to Engineering Cooperative Education | |
| CME 203 | Material & Energy Balances | |
| CME 211 | Introduction to Thermodynamics for Chemical Engineers | 3 |
| CME 281 | Chemical Engineering Computations | |
| CME 306 | Chemical Reaction Kinetics & Engineering | |
| CME 311 | Chemical Engineering Thermodynamics | |
| CME 324 | Transport Phenomena I | |
| CME 325 | Transport Phenomena II | |
| CME 326L | Transport Phenomena Laboratory | |
| CME 365 | Separation Techniques | |
| CME 381 | Advances Mathematics for Chemical Engineers | 3 |
| CME 408 | Seminar (2 semesters) | |
| CME 430 | Chemical Engineering Design I | |
| CME 431 | Chemical Engineering Design II | |
| CME 452 | Process Control | |
| CME 453L | Process Control Laboratory | |
| CME 465 | Fluid Flow & Heat Transfer Processes | |
| CME 466L | Chemical Engineering Unit Operations Laboratory | 2 |
| CMM 100 | Principles of Oral Communication | |
| EGR 102 | Introduction to the University Experience for Engineers | 0 |
| EGR 103 | Engineering Innovation | |
| EGR 150 | Enrichment Workshop I | 0 |
| EGR 151 | Enrichment Workshop II | 0 |
| EGR 201 | Engineering Mechanics | |
| EGR 203 | Electrical & Electronic Circuits | |
| ENG 100 & ENG 200 | Writing Seminar I and Writing Seminar II | 6-8 |
| or ENG 114 | First-Year Writing Seminar | |
| or ENG 198 | Honors Writing Seminar | |
| HST 103 | The West & the World | |
| or HST 198 | History Scholars' Seminar | |
| MTH 168 | Analytic Geometry & Calculus I | |
| MTH 169 | Analytic Geometry & Calculus II | |
| MTH 218 | Analytic Geometry & Calculus III | |
| MTH 219 | Applied Differential Equations | |
| PHL 103 | Introduction to Philosophy | 3,4 |
| PHY 206 | General Physics I - Mechanics | |
| PHY 207 | General Physics II - Electricity & Magnetism | |
| REL 103 | Introduction to Religious and Theological Studies | |
| SSC 200 | Social Science Integrated | |
| Chemistry or Biology elective [1] | | 3 |
| CME elective [1] | | 3 |
| Elective [2] | | 3 |
| Electives | | 12 |
| Engineering/Science electives [6] | | 1 |
| Total Hours | | 137 |

1. Must be selected from list approved by the Chemical and Materials Engineering Department.
2. Must be selected from approved list of PHL or REL ethics courses.

# Concentration in Energy Systems-Chemical (CES)

This concentration is open to all engineering students. The Energy Systems Concentration provides an interdisciplinary concentration in energy systems and its social consequences. Students completing this concentration will be prepared for jobs in both industrial and building energy systems, a rapidly growing market.

| | | |
|---|---|---|
| ASI 320 | Cities & Energy [1,2] | 3 |
| CME 203 | Material & Energy Balances | 3 |
| CME 311 | Chemical Engineering Thermodynamics | 3 |
| CME 324 | Transport Phenomena I | 3 |
| CME 325 | Transport Phenomena II | 3 |
| CME 326L | Transport Phenomena Laboratory | 1-2 |
| CME 430 | Chemical Engineering Design I | 3 |

| | | |
|---|---|---|
| CME 431 | Chemical Engineering Design II | 3 |
| CME 465 | Fluid Flow & Heat Transfer Processes | 3 |
| CME 466L | Chemical Engineering Unit Operations Laboratory | 2 |
| **CME elective** | | |
| Select one course from: | | 3 |
| CME 486 | Introduction to Petroleum Engineering | |
| or CME 586 | Introduction to Petroleum Engineering | |
| CME 524 | Electrochemical Power | |
| or MEE 575 | Fracture & Fatigue of Metals & Alloys I | |
| CME 565 | Fundamentals of Combustion | |
| CME 574 | Fundamentals of Air Pollution I | |
| Select two courses from: | | 6 |
| Select any CME elective course above [3] | | |
| AEE 560 | Propulsion Systems | |
| or MEE 560 | Propulsion Systems | |
| CME 507 | Advanced Thermodynamics | |
| or MEE 511 | Advanced Thermodynamics | |
| CME 579 | Materials for Advanced Energy Applications | |
| or MAT 579 | Materials for Advanced Energy Applications | |
| MEE 413 | Propulsion | |
| or MEE 513 | Propulsion | |
| MEE 420 | Energy Efficient Buildings | |
| or MEE 569 | Energy Efficient Buildings | |
| MEE 471 | Design of Thermal Systems | |
| or MEE 571 | Design of Thermal Systems | |
| MEE 473 | Renewable Energy Systems | |
| or MEE 573 | Renewable Energy Systems | |
| MEE 478 | Energy Efficient Manufacturing | |
| or MEE 578 | Energy Efficient Manufacturing | |
| Total Hours | | 36-37 |

1 Or another approved humanities elective related to Energy Systems.

2 Satisfies History requirement.

3 Course cannot have already been chosen as CME elective.

# Minor in Bioengineering (BIE)

This minor is open to chemical, civil, computer, electrical, and mechanical engineering majors. The program is designed to expose the student to the use of engineering principles in biological systems and applications.

| | | |
|---|---|---|
| BIO 151 | Concepts of Biology I: Cellular & Molecular Biology | 3 |
| or BIO 152 | Concepts of Biology II: Evolution & Ecology | |
| CME 490/590 | Introduction to Bioengineering | 3 |
| Select one course from: | | 3 |
| CME 491/591 | Biomedical Engineering I | |
| MEE 430/530 | Biomechanical Engineering | |
| Select one course from: [1] | | 3 |
| BIE 503 | Principles of Biology for Bioengineers | |
| BIE 507 | Bioengineering Experimentation Techniques | |
| BIE 511 | Biomaterials | |
| BIE 595 | Special Problems in Bioengineering | |
| BIO 151 | Concepts of Biology I: Cellular & Molecular Biology | |
| BIO 152 | Concepts of Biology II: Evolution & Ecology | |
| BIO 312 | General Genetics | |
| BIO 403 | Physiology I | |
| BIO 411 | General Microbiology | |
| BIO 440 | Cell Biology | |
| CHM 420 | Biochemistry | |
| CHM 451 | General Biochemistry I | |
| CHM 452 | General Biochemistry II | |
| CME 491/591 | Biomedical Engineering I | |
| CME 492 | Chemical Sensors & Biosensors | |
| CME 523/ BIE 551 | Transport Phenomena in Biological Systems | |
| CME/MAT 530 | Biomaterials | |
| CME 533 | Biofuel | |
| CME/CEE/BIE 560 | Biological Processing of Wastewater | |
| MEE 430 | Biomechanical Engineering | |
| or MEE 530 | Biomechanical Engineering | |
| Total Hours | | 12 |

1 Course cannot have already been chosen above.

# Minor in Chemical Processing (CHP)

This minor is open to civil, computer, electrical, and mechanical engineering majors. The program is designed to acquaint the student with industrial operations in the chemical process industries such as heat exchange, distillation, extraction, humidification, etc. The elective courses cover a wide range of topics to accommodate the student's special interests.

| | | |
|---|---|---|
| CME 203 | Material & Energy Balances | 3 |
| CME 324 | Transport Phenomena I | 3 |
| CME 365 | Separation Techniques | 3 |
| Select one course from: | | 3 |
| CME 306 | Chemical Reaction Kinetics & Engineering | |
| CME 430 | Chemical Engineering Design I | |
| CME 452 | Process Control | |
| CME 465 | Fluid Flow & Heat Transfer Processes | |
| CME 499 | Special Problems in Chemical Engineering | |
| Total Hours | | 12 |

# Minor in Composite Materials Engineering (CMA)

This minor is open to chemical, civil, and mechanical engineering majors. The program is designed to expose the student to the design, processing, and characterization of composite materials and their various applications in industry.

| | | |
|---|---|---|
| CME 510 | High Performance Thermoset Polymers | 3 |
| or MAT 510 | High Performance Thermoset Polymers | |
| CME 512 | Advanced Composites | 3 |
| or MAT 542 | Advanced Composites | |
| Select two courses from: | | 6 |
| CEE 540 | Composites Design | |
| or MAT 540 | Composite Design | |

| | | |
|---|---|---|
| CEE 543 | Analytical Mechanics Composite Materials | |
| or MAT 543 | Analytical Mechanics of Composite Materials | |
| CEE 546 | Finite Element Analysis I | |
| or MEE 546 | Finite Element Analysis I | |
| CME 509 | Introduction to Polymer Science - Thermoplastics | |
| or MAT 509 | Introduction to Polymer Science-Thermoplastics | |
| CME 527 | Methods of Polymer Analysis | |
| or MAT 527 | Methods of Polymer Analysis | |
| CME 528 | Chemical Behavior of Materials | |
| or MAT 528 | Chemical Behavior of Materials | |
| CME 580 | Polymer Decomposition, Degradation & Durability | |
| or MAT 580 | Polymer Durability | |
| Total Hours | | 12 |

# Minor in Energy Production Engineering (EPE)

This minor is open to all engineering majors. A selection of courses covering the production of energy:

| | | |
|---|---|---|
| Select four courses from: | | 12 |
| BIE/CME/RCL 533 | Biofuel | |
| CME 486/586 | Introduction to Petroleum Engineering | |
| CME/MEE/RCL 524 | Electrochemical Power | |
| CHM/GEO 234 | Energy Resources | |
| ECE 316 | Introduction to Electrical Energy Systems | |
| ECE 583 | Advanced Photovoltaics | |
| MAT 579 | Materials for Advanced Energy Applications | |
| MEE 473/573/RCL 573 | Renewable Energy Systems | |
| RCL 590 | Special Problems in Renewable & Clean Energy [1] | |
| RCL 590 | Special Problems in Renewable & Clean Energy [2] | |
| RCL 590 | Special Problems in Renewable & Clean Energy [3] | |
| Total Hours | | 12 |

1 Must be Thermal Systems Analysis.

2 Must be Solar Energy Engineering.

3 Must be Wind Energy Engineering.

# Minor in Materials Engineering (MAT)

This minor is open to all engineering majors. A general overview of materials with choice courses in polymers, composites, nanomaterials, and material characterization.

| | | |
|---|---|---|
| MAT 501 | Principles of Materials I | 3 |
| MAT 502 | Principles of Materials II | 3 |
| Select two courses from: | | 6 |
| CME 509 | Introduction to Polymer Science - Thermoplastics | |
| or MAT 509 | Introduction to Polymer Science-Thermoplastics | |
| CME 510 | High Performance Thermoset Polymers | |
| or MAT 510 | High Performance Thermoset Polymers | |
| CME 511 | Principles of Corrosion | |
| or MAT 511 | Principles of Corrosion | |
| CME 512 | Advanced Composites | |
| or MAT 542 | Advanced Composites | |
| CME 527 | Methods of Polymer Analysis | |
| or MAT 527 | Methods of Polymer Analysis | |
| CME 528 | Chemical Behavior of Materials | |
| or MAT 528 | Chemical Behavior of Materials | |
| CME 579 | Materials for Advanced Energy Applications | |
| or MAT 579 | Materials for Advanced Energy Applications | |
| CME 580 | Polymer Decomposition, Degradation & Durability | |
| or MAT 580 | Polymer Durability | |
| MAT 504 | Techniques of Materials Analysis | |
| MAT 506 | Mechanical Behavior of Materials | |
| MAT 507 | Introduction to Ceramic Materials | |
| MAT 508 | Principles of Material Selection | |
| MAT 521 | NDE/SHM | |
| MAT 535 | High Temperature Materials | |
| MAT 541 | Experimental Mechanics of Composite Materials | |
| MAT 543 | Analytical Mechanics of Composite Materials | |
| MAT 544 | Mechanics of Composite Materials | |
| MAT 575 | Fracture & Fatigue of Metals & Alloys I | |
| MAT 577 | Light Structural Metals | |
| MAT 590 | Selected Readings in Materials Engineering | |
| MAT 595 | Special Problems in Materials Engineering | |
| MAT 601 | Surface Chemistry of Solids | |
| MAT 604 | Nanostructured Materials | |
| MEE 312 | Engineering Materials I | |
| Total Hours | | 12 |

# Minor in Polymer Materials (PME)

This minor is open to all engineering majors. Coverage of polymers including thermosets and thermoplastics, and composite materials in which polymers are used as constituents. Methods of polymer processing and polymer characterization are also included.

| | | |
|---|---|---|
| CME 509 | Introduction to Polymer Science - Thermoplastics | 3 |
| or MAT 509 | Introduction to Polymer Science-Thermoplastics | |
| CME 510 | High Performance Thermoset Polymers | 3 |
| or MAT 510 | High Performance Thermoset Polymers | |
| Select two courses from: | | 6 |
| CME 512 | Advanced Composites | |
| or MAT 542 | Advanced Composites | |
| CME 527 | Methods of Polymer Analysis | |
| or MAT 527 | Methods of Polymer Analysis | |
| CME 528 | Chemical Behavior of Materials | |
| or MAT 528 | Chemical Behavior of Materials | |
| CME 580 | Polymer Decomposition, Degradation & Durability | |
| or MAT 580 | Polymer Durability | |
| MAT 540 | Composite Design | |
| MAT 543 | Analytical Mechanics of Composite Materials | |
| Total Hours | | 12 |

**First Year**

| Fall | Hours | Spring | Hours |
|---|---|---|---|
| ENG 100 (Satisfies CAP Writing Seminar Requirement) | 3 | HST 103 (Satisfies CAP First Year Humanities Common | 3 |
| PHL 103 (Satisfies CAP First Year Humanities Common) | 3 | REL 103 (Satisfies CAP First Year Humanities Common | 3 |
| CHM 123 | 3 | CHM 124 | 3 |
| CHM 123L | 1 | CHM 124L | 1 |
| MTH 168 (Satisfies CAP Math Requirement) | 4 | MTH 169 | 4 |
| EGR 103 | 2 | PHY 206 (Satisfies CAP Natural Science) | 3 |
| EGR 102 | 0 | CME 101 | 0-1 |
| EGR 150 | 0 | EGR 151 | 0 |
| | 16 | | 17-18 |

**Second Year**

| Fall | Hours | Spring | Hours |
|---|---|---|---|
| ENG 200 (Satisfies CAP Second Year Writing Seminar) | 3 | CMM 100 (Satisfies CAP Communication) | 3 |
| CME 203 | 3 | CME 281 | 3 |
| CME 211 | 3 | CME 311 | 3 |
| CHM 313 | 3 | CHM 314 | 3 |
| CHM 313L | 1 | CHM 314L | 1 |
| MTH 218 | 4 | MTH 219 | 3 |
| COP 200 or EGR 200 | 0 | | |
| | 17 | | 16 |

**Third Year**

| Fall | Hours | Spring | Hours |
|---|---|---|---|
| CAP Art Study | 3 | CAP Adv PHL or REL | 3 |
| CME 324 | 3 | CME 306 | 3 |
| CME 381 | 3 | CME 365 | 3 |
| PHY 207 | 3 | CME 325 | 3 |
| SSC 200 (Satisfies CAP Socail Science) | 3 | CME 326L | 2 |
| EGR 201 | 3 | EGR 203 | 3 |
| | 18 | | 17 |

**Fourth Year**

| Fall | Hours | Spring | Hours |
|---|---|---|---|
| CAP Adv HST | 3 | CAP Adv PHL or REL | 3 |
| CME 430 | 3 | CME 431 | 3 |
| CME 465 | 3 | CME 453L | 2 |
| CME 466L (Satisfies CAP Capstone Requirement) | 2 | CME Advanced Elective | 3 |
| CME 452 | 3 | CME 408 | 0-1 |
| CME 408 | 0-1 | EGR/SCI EL | 6 |
| CHM/BIO Elective | 3 | | |
| | 17-18 | | 17-18 |

Total credit hours: 135-138

## Courses

**CME 101. Introduction to Chemical Engineering. 0-1 Hours**
Introduction to the chemical engineering faculty, facilities, and curriculum; survey of career opportunities in chemical engineering. Introduction to the University first-year experience.

**CME 198. Research & Innovation Laboratory. 1-6 Hours**
Students participate in (1) selection and design, (2) investigation and data collection, (3) analysis and (4) presentation of a research project. Research can include, but is not limited to, developing an experiment, collecting and analysing data, surveying and evaluating literature, developing new tools and techniques including software, and surveying, brainstorming and evalutating engineering solutions and engineering designs. Proposals from terams of students will be considered.

**CME 200. Professional Development Seminar. 0-1 Hours**
Presentations on contemporary and professional engineering subjects by students, faculty, and engineers in active practice. The seminar addresses topics in key areas that complement traditional courses and prepare distinctive graduates, ready for life and work. Registration required for all sophomore students.

**CME 203. Material & Energy Balances. 3 Hours**
Introductory course on the application of mass and energy conservation laws to solve problems typically encountered in chemical process industries. Prerequisite(s): CHM 123; MTH 138 or 168. Corequisite(s): CME 211.

**CME 211. Introduction to Thermodynamics for Chemical Engineers. 3 Hours**
First law of thermodynamics, states of matter, equations of state, open and closed system energy balances, reactive energy balances, entropy, 2nd law of thermodynamics, introduction to power cycles and refrigeration. Prerequisite(s): PHY 206; CHM 123; MTH 138 or 168.

**CME 281. Chemical Engineering Computations. 3 Hours**
Development of computational skills with an emphasis on algorithm development and problem solving. Computational skills are applied to typical problems in chemical engineering, engineering data analysis and statistics. Corequisite(s): CME 203, MTH 169.

**CME 298. Research & Innovation Laboratory. 1-6 Hours**
Students participate in (1) selection and design, (2) investigation and data collection, (3) analysis and (4) presentation of a research project. Research can include, but is not limited to, developing an experiment, collecting and analyzing data, surveying and evaluating literature, developing new tools and techniques including software, and surveying, brainstorming and evaluating engineering solutions and engineering designs. Proposals from teams of students will be considered.

**CME 306. Chemical Reaction Kinetics & Engineering. 3 Hours**
Chemical reaction kinetics, ideal reactor analysis and design, multiple reactor/reaction systems, and heterogeneous catalysis. Prerequisite(s): CME 311. Corequisite(s): CME 324.

**CME 311. Chemical Engineering Thermodynamics. 3 Hours**
Development and application of the fundamental principles of chemical thermodynamics: Vapor/liquid equilibrium, solution thermodynamics, chemical reaction equilibria, and thermodynamic analysis of chemical engineering processes. Prerequisite(s): CME 203; CME 211; MTH 218.

**CME 324. Transport Phenomena I. 3 Hours**
Viscosity, shell momentum balances, isothermal equations of change, thermal conductivity, shell energy balances, non-isothermal equations of change, mass diffusivity, shell species mass balances, equations of change for multicomponent systems. Prerequisite(s): CME 203, CME 281; MTH 219. Corequisite(s): CME 381.

**CME 325. Transport Phenomena II. 3 Hours**
Multidimensional momentum, energy, and mass transport, dimensionless parameters, turbulence and numerical solution methods. Prerequisite(s): CME 324, CME 381.

**CME 326L. Transport Phenomena Laboratory. 1-2 Hours**
Viscosity, conductivity, diffusion coefficient measurements, velocity, temperature, concentration profiles, engineering instrumentation, and experimental error analysis. Prerequisite(s): CHM 124L; CME 324. Corequisite(s): CME 325.

**CME 365. Separation Techniques. 3 Hours**
Equilibrium staged separations: distillation, extraction and absorption, with an emphasis on distillation. Prerequisite(s): CME 311, CME 324.

**CME 381. Advances Mathematics for Chemical Engineers. 3 Hours**
Study of analytical and numerical techniques to support upper-level chemical engineering classes. Vector analysis, matrices, differential equations, numerical integration and differentiation, root finding, and curve fitting ordinary and partial differential equations. Prerequisite(s): CME 281; MTH 219.

**CME 398. Research & Innovation Laboratory. 1-6 Hours**
Students participate in (1) selection and design, (2) investigation and data collection, (3) analysis and (4) presentation of a research project. Research can include, but is not limited to, developing an experiment, collecting and analyzing data, surveying and evaluating literature, developing new tools and techniques including software, and surveying, brainstorming and evaluating engineering solutions and engineering designs. Proposals from teams of students will be considered.

**CME 408. Seminar. 0-1 Hours**
Presentation of lectures on contemporary chemical engineering subjects by students, faculty, and engineers in active practice. Registration required of senior students only. Corequisite(s): CME 430.

**CME 409. Introduction to Polymer Science - Thermoplastics. 3 Hours**
Broad technical overview of the nature of synthetic macromolecules, including the formation of polymers and their structure, structure-property relationships, polymer characterization and processing, and applications of polymers. Fundmental topics such as viscoelasticity, the glassy state, time-temperature superposition, polymer transitions, and free volume will also be reviewed. The course focuses on thermoplastic polymers. Prerequisite(s): CHM 313, PHY 206, MTH 219.

**CME 410. High Performance Thermoset Polymers. 3 Hours**
Survey of high performance thermoset resins, focusing on chemistry, processing and properties of six general resin families; vinyl ester, epoxy, phenolic, cyanate ester, bismaleimide, and polyimides. The course will include fundamental discussions of polymerization mechanisms, network structure development, rheology and time-temperature transformation, resin toughening, and structure-processing-property relationships. Characterization techniques will also be reviewed. Prerequisite(s): CHM 313.

**CME 412. Advanced Composites. 3 Hours**
Materials and processing. Comprehensive introduction to advanced fiber reinforced polymeric matrix composites. Constituent materials and composite processing will be emphasized with special emphasis placed on structure-property relationships, the role of matrix in composite processing, mechanical behavior, and laminate processing. Specific topics will include starting materials, material forms, processing, quality assurance, test, methods, and mechanical behavior. Prerequisite(s): (CME 409 or CME 509 or MAT 501) or permission of instructor.

**CME 429. Computational Chemistry. 3 Hours**
Introduction to computational chemistry including a discussion of ab initio, semiempical, and DFT methods and an overview of molecular mechanics and molecular simulation methods. Lectures are supplemented by simulation exercises using commercial programs such a Gaussian and Molecular Studio. Prerequisite(s): CHM 124 or permission of instructor.

**CME 430. Chemical Engineering Design I. 3 Hours**
Study of basic design concepts, safety and health issues, capital cost estimation, manufacturing cost estimation, basic economics and profitability analysis, materials of construction, materials selection and process vessel design. Prerequisite(s): CME 203; CME 306. Corequisite(s): CME 465.

**CME 431. Chemical Engineering Design II. 3 Hours**
Project-based study of principles of process design and economics, use of process flowsheet simulators, short-cut design procedures, process optimization, and plant layout. Prerequisite(s): CME 306, CME 365, CME 430, CME 465.

**CME 432. Chemical Product Design. 3 Hours**
Application of the design process to products based on chemical technology. Coverage of the entire design process from initial identification of product needs, to the generation and selection of product ideas, and culminating in the manufacture of a new product.

**CME 452. Process Control. 3 Hours**
Mathematical models, Laplace transform techniques, and process dynamics. Feedback control systems, hardware, and instrumentation. Introduction to frequency response, advanced techniques, and digital control systems. Prerequisite(s): CME 381. Corequisite(s): CME 306.

**CME 453L. Process Control Laboratory. 2 Hours**
Team-based, project oriented study of process dynamics and digital control using computer-based data acquisition and control systems with a focus on real time process monitoring and control. Prerequisite(s): (CME 452, CME 466L) or permission of instructor.

**CME 465. Fluid Flow & Heat Transfer Processes. 3 Hours**
Fluid mechanics, transportation and metering of fluids, heat transfer and its applications. Prerequisite(s): CME 311, CME 324.

**CME 466L. Chemical Engineering Unit Operations Laboratory. 2 Hours**
Study of the equipment and utilization of various chemical engineering processes. Team based experimentation includes designing, and performing experiments on common chemical process unit operations apparatuses. After experimentation, students analyze data and compare with literature for experiment validation. Report writing and group presentations are emphasized. Prerequisite(s): CME 365. Corequisite(s): CME 465.

**CME 486. Introduction to Petroleum Engineering. 3 Hours**
Introduction to the fundamental concepts in petroleum engineering. Petroleum topics include overviews of areas such as petroleum geology, petroleum fluids and thermodynamics, drilling and completion, and production and multiphase flow. In addition this course will cover refinery operations.

**CME 489. Principles of Biology for Bioengineers. 3 Hours**
This course is designed for students with undergraduate majors in engineering or non-biological sciences. The focus of the course is to provide a common broad base of basic knowledge and terminology in the biological sciences required for coursework in the bioengineering emphasis tracts. Prerequisite(s): (BIO 151, BIO 152) or permission of instructor.

**CME 490. Introduction to Bioengineering. 3 Hours**
This class provides an introduction to bioengineering - a branch of engineering focusing on biological systems, biomaterials, engineering applications in living systems, and many other areas. By the end of this course, students will be able to understand bioengineering applications and processes, and properly apply engineering fundamentals, including transport phenomena and reaction kinetics, to these systems. Prerequisite(s): ((BIO 151 or BIO 152); (CME 324 or MEE 308)) or permission of instructor.

**CME 491. Biomedical Engineering I. 3 Hours**
Introduction to the fundamental concepts in biomedical engineering with a special focus on chemical engineering applications. Biomedical topics include overviews of areas such as biomaterials, tissue engineering, biosensors and biomedical engineering technology. Prerequisite(s): ((BIO 151 or BIO 152); CME 324) or permission of instructor.

**CME 492. Chemical Sensors & Biosensors. 3 Hours**
Analysis performed with chemical sensors complement laboratory analyses and offer the potential for more rapid and on-line analyses in complex sample matrices. The demand for new chemical sensors, biosensors, and sensing concepts is rapidly increasing and associated with the growing need to understand and/or control complex chemical and biochemical processes or detect the presence of toxic chemical or biological agents. Prerequisite(s): Permission of instructor.

**CME 493. Honors Thesis. 3 Hours**
Selection, design, investigation, and completion of an independent, original research study resulting in a document prepared for submission as a potential publication and a completed undergraduate thesis. Restricted to students in University Honors Program.

**CME 494. Honors Thesis. 3 Hours**
Selection, design, investigation, and completion of an independent, original research study resulting in a document prepared for submission as a potential publication and a completed undergraduate thesis. Restricted to students in University Honors Program. Prerequisite(s): CME 493.

**CME 498. Research & Innovation Laboratory. 1-6 Hours**
Students participate in (1) selection and design, (2) investigation and data collection, (3) analysis and (4) presentation of a research project. Research can include, but is not limited to, developing an experiment, collecting and analyzing data, surveying and evaluating literature, developing new tools and techniques including software, and surveying, brainstorming and evaluating engineering solutions and engineering designs. Proposals from teams of students will be considered.

**CME 499. Special Problems in Chemical Engineering. 1-6 Hours**
Particular assignments to be arranged and approved by chairperson of the department.