DEPARTMENT OF CHEMICAL AND MATERIALS ENGINEERING

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Chemical Engineering Program. The Chemical Engineering Program is an ABET Accredited Program that combines the science of chemistry with the discipline of engineering in order to solve problems and to increase process efficiency. One of the most attractive aspects of a chemical engineering future is the variety of work available. The Chemical Engineering Program is a blend of physics, chemistry, and mathematics; thus, a chemical engineer possesses a versatility that gives him or her many opportunities for employment in fields such as energy systems, pulp and paper, environmental engineering, food products, nuclear power, petroleum and petrochemicals, semiconductors, synthetic fuels, radioisotope applications, plastics and polymers, pharmaceuticals, education, biomedical engineering, computer applications, alternate energy sources, steel, nano technology and textiles. A chemical engineer can choose work in any of the following areas: research and development, design and construction, operations, management, teaching, or technical sales.

The mission of the Chemical Engineering Program is to provide quality educational programs firmly based in fundamental concepts and to perform and publish outstanding chemical engineering research. The goals of the Chemical Engineering Program are (1) to prepare students with a broad-based education grounded in chemical engineering fundamentals, (2) to maintain an environment that promotes effective student/faculty involvement in teaching, research, and mentoring, (3) to promote an active interaction with regional industries, and (4) to graduate students capable of independent life long learning. In addition, the educational objective of the Department of Chemical and Materials Engineering is to prepare students who (1) are well grounded in the fundamentals of chemical engineering, (2) can understand, analyze, and design efficient processes, (3) are proficient in the oral and written communication of their work and ideas, (4) are able to work in multidisciplinary teams in conjunction with their design, formulation of problems, and conducting of experiments, (5) understand the safety and environmental consequences of their work, and (6) are instilled with a sense of social responsibility, ethics, and a commitment to life-long learning. Progress towards these goals and objectives is assessed by student performance on the nationally administered Fundamentals in Engineering Examination, performance at international design competitions, exit interviews with graduating students, and surveys of graduated students and their employers.

The faculty of the Chemical Engineering Program is dedicated to excellence in teaching. It is the faculty's goal to provide the students with a strong, well-rounded background for immediate entry into the industrial workforce or for graduate study. This background includes the theoretical aspects of chemical engineering as well as practical work experiences. Thus, most of the equipment that is installed in the Chemical Engineering laboratory is on the scale of pilot plant equipment. Because much of the equipment is made of glass, students are able to see at a glance what processes occur and where the streams are flowing. The department has a two-story distillation column, a gas absorber, two-stage evaporator, two types of chemical reactors, a catalytic reactor, liquid extraction equipment, membrane based gas separation, an Atomic Force Microscope (AFM) system, a multiple column micro gas chromatograph, process control lab, and supporting analytical equipment such as gas chromatographs. All of this equipment is used by undergraduate students. Proof that the program's goals are being achieved is in the job-placement statistics for chemical engineers from UI. Most receive job offers before graduation and many graduates now hold high-level technical and management positions in industry, government, and academia.

The department has available a number of fellowships and assistantships for students. Support includes fellowships from industry and alumni; UI graduate assistantships; and research assistantships. Entering graduate students must normally hold a B.S. in chemical engineering. Students entering the graduate program in the Chemical Engineering Program can work towards an M.S., M.Engr., or Ph.D. degree. The graduate program also includes provisions for study leading to an M.S. in Chemical Engineering for students who have a B.S. degree in a related field. Students will be required to register as undergraduates for as many semesters as it takes to meet prerequisites to the courses required in the M.S. (Ch.E.) degree program.

Graduate studies in this department are highly diversified in order to accommodate the needs of most students who have a good basic background in the physical sciences, mathematics, and engineering. Areas of expertise include chemical reaction engineering; simulation, optimization and process design especially for energy systems, pulp and paper and food applications; hazardous waste characterization and bioremediation; membrane, nano-science, fluid mechanics, biochemical engineering; and mass transfer research. The graduate program in chemical engineering requires a total GRE score of at least (Analytical >500 and Quantitative >725), as well as a TOEFL score of at least 550 (paper based) or 225 (computer based).

Material Science and Engineering Program. The educational objectives of the Material Science and Engineering Program are to educate graduates who will: (1) Use their mathematics and science background to formulate and solve engineering problems. (2) Remain current in modern technology and in tools of engineering practice. (3) Demonstrate an understanding of current economic and societal issues associated with engineering projects and their impacts. (4) Be able to communicate effectively with engineers and non-engineers while working independently or on teams to develop engineering solutions. (5) Demonstrate an understanding of their professional and ethical responsibilities as engineers and uphold their responsibility to the public and occupational health and safety. (6) Demonstrate the importance of life-long learning and continued professional growth.

Our Materials Science and Engineering Program is an ABET Accredited program and its educational mission is to produce graduates who are equipped to begin competitive and productive careers in their engineering professions; who can define and solve material science and engineering problems to meet desired needs and produce societal benefits; and who understand the importance of working responsibly, acting ethically and pursuing professional growth.

Although the program emphasizes economics and technology, engineering training also includes environment concerns, ethical behavior, and safety concerns. As technological and engineering fields, these professional disciplines offer tremendous opportunities for the person who wishes to become involved in the application of material science and engineering, often in sophisticated designs, to the preservation and enhancement of our society. The program provides the technical training to prepare our graduates for productive and rewarding engineering careers.

The laboratory facilities for materials science and engineering include: state of the art magnetic and thin film, electrical and optical materials characterization, semiconductor processes including thin film sputtering and deposition, inductively coupled plasma processing, electron cyclotron resonance plasma dry etching, chemical mechanical planarization, mechanical alloying, vacuum arc furnaces, combustion synthesis, clean room, electron beam lithography, ion beam technology, electro-chemistry, computer chip and bio-chip design, micro-electromechanical systems (MEMS), nano-materials, nano-devices and other state of the art technologies including optical and transmission electron microscopy, atomic force microscopy, scanning electron microscopy, x-ray diffraction, focused ion beam, differential scanning calorimetry and thermogravimetric analysis, etc. These laboratories provide an understanding of nano scale technology, magnetic, electronic, bio-active, ceramic, polymeric, metallic and intermetallic materials.

Our faculty has proven their qualifications by their credentials in national and international professional societies. They are well known by their publications, research, and contract work. Most students find employment in the summer or on a cooperative basis, so that they can become more intimately involved in the disciplines that they are studying. Exposure to the department faculty members provides students with a one-to-

one interaction and an expertise that enables them to be truly competitive when they enter the real world.

The program is designed to take advantage of the other excellent facilities of the university and other engineering disciplines. The program of study also includes involvement with practical aspects of professional practice by exposure to the regional industries and research groups through field trips, guest speakers, study problems, and work time during the summer.

A minor in Materials Science and Engineering is offered which integrates nicely with majors in chemical or mechanical engineering along with other engineering and science disciplines. This minor allows the graduate to combine expertise in materials with another technical discipline.

A minor in Metallurgical Engineering is offered and integrates nicely with majors in either chemical or materials engineering. This minor allows the graduate to specialize in the minerals processing area of metal materials, fabrications, and research.

The Advanced Materials Technology Certificate is a graduate level certificate open for working professionals or graduate students with a Bachelor degree in engineering or sciences (physical sciences preferred). The level of educational proficiency will be judged on a case-by-case basis; and thus it is possible that the student may need to take preparatory courses before they can register for the required courses.

The program offers the Master of Science (M.S.) and the Doctor of Philosophy (PhD) degrees in materials science and engineering. These programs include a mix of theoretical and practical study most appropriate to each student. Studies include topics on nano-technology, electronic materials, alternative energy materials (nuclear, solar, etc.), and advanced materials processing techniques, as well as other traditional materials science areas, such as corrosion, welding, powder metallurgy etc.. Some students prefer to work on applied problems that are presented by industry or research establishments in the area, generally with funding from outside sources. Studies can be tailored to individual interests.

These advanced studies are financed by research grants, an industry sponsor, or occasionally by departmental funding. They are designed to train the individual in research methods and investigative procedures that will later enhance his or her ability in industrial or research environments or in teaching. The master's program involves both class work and research; the latter being designed to familiarize the student with research methods. In the doctoral program, the student is expected to break new ground and advance the field both scientifically and to maintain the competitive technological lead enjoyed in the U.S. for so many years. The master's program generally requires 12 to 24 months beyond the baccalaureate degree and the doctoral program usually entails at least three years beyond the baccalaureate degree.

Most students find employment in the summer or on a cooperative basis, so that they can become more intimately involved in the processes that they are studying. The total program enables the person to leave the university with confidence, either as a baccalaureate student or at the master's or doctoral level, with the capability of a truly competent professional. Metallurgical and materials engineers have a wide variety of career options. This ranges all the way from primary metals/ceramics/polymer production through advanced materials industries. There are opportunities in technological areas with names and processes not even dreamed of just a few decades ago: plasma extractive processing, ceramic powder synthesis, bio-corrosion, magnetic recording media, and electron microscopy. The materials produced are formed into all of the products we use in our daily lives, such as our cars, home appliances, farm equipment, and electrical and electronic equipment. Some of our graduates are employed as engineering consultants or by government agencies. In fact, everything we touch, with the exception of agricultural or forestry products, has had its origin as a mineral in the earth. Materials engineers and materials scientists also develop new products to fit specific demands, such as materials to withstand high stress, high temperature environments, or the extreme cold of outer space.

Courses

See the course description section for courses in Chemical Engineering (ChE) and Materials Science & Engineering (MSE).

Chemical and Materials Engineering Undergraduate Curricular Requirements

Chemical Engineering (B.S.Ch.E.)

Required course work includes the university requirements (see regulation J-3) and:

ChE 110	Introduction to Chemical Engineering (1 cr)
ChE 123	Computations in Chemical Engineering (2 cr)
ChE 210	Integrated Chemical Engineering Fundamentals
ChE 223	Material and Energy Balances (3 cr)
ChE 326	Chemical Engineering Thermodynamics (3 cr)
ChE 330	Separation Processes I (3 cr)
ChE 340	Transport and Rate Processes I (4 cr)
ChE 341	Transport and Rate Processes II (4 cr)
ChE 423	Reactor Kinetics and Design (3 cr)
ChE 433, ChE 434	Chemical Engineering Lab I, II (2 cr)
ChE 444	Process Analysis and Control (3 cr)
ChE 445	Digital Process Control (3 cr)
ChE 453	Process Analysis and Design I (3 cr)
ChE 454	Process Analysis and Design II (3 cr)
ChE 491	Seminar (1 cr)
Chem 111	Principles of Chemistry I (4 cr)
Chem 112	Principles of Chemistry II (5 cr)
Chem 277, Chem 278	Organic Chemistry I and Lab (4 cr)
Chem 305, Chem 307	Physical Chemistry and Lab (4 cr)
Chem 372, Chem 374	Organic Chemistry II and Lab (4 cr)
Engr 210	Engineering Statics (3 cr)
Engr 240	Introduction to Electrical Circuits (3 cr)
Engr 320	Engineering Thermodynamics and Heat Transfer (3 cr)
Engr 335	Engineering Fluid Mechanics (3 cr)
Math 170	Analytic Geometry and Calculus (4 cr)
Math 175	Analytic Geometry and Calculus II (4 cr)
Math 275	Analytic Geometry and Calculus III (3 cr)
Math 310	Ordinary Differential Equations (3 cr)
Phys 211	Engineering Physics I (3 cr)
Phys 212	Engineering Physics II (3 cr)

Chemical engineering or Material Science and Engineering numbered 390 or greater technical electives (3 cr)
Chemical/bioscience elective course (3 cr)
Chemical/bioscience elective lab (1 cr)
Computer science elective in a programming language (3 cr)
Economics elective (3 cr)
Humanities and Social Sciences electives (9 cr)
Communication electives (2 cr)
Mathematics electives numbered 300 or greater (excluding any 398, 498, or 598 Internship) (3 cr)
Technical electives in math, science, or engineering numbered 300 or greater (6 cr)

Courses to total 128 credits for this degree, not counting Engl 101, any 398 (Internship), any 498 (Internship), any 598 (Internship), or mathematics courses numbered lower than Math 170, and other courses that might be required to remove deficiencies.

Students majoring in chemical engineering must earn a grade of C or better in each of the following courses before registration is permitted in upper-division chemical engineering courses: Chem 111 and Chem 112; ChE 223; Engr 210, Engr 320, and Engr 335; and Math 275 and Math 310.

Students transferring ChE 223 or its equivalent from a university without an ABET accredited chemical engineering program must pass a test on the subject matter of this course before acceptance of the course for certification.

A passing grade is required in each of the following courses before registration is permitted in upper-division chemical engineering courses: ChE 123, computer science elective, Engl 102, Math 170 and Math 175, and Phys 211 and Phys 212.

Any student majoring in chemical engineering may accumulate no more than four grades of D or F in UI mathematics, science, or engineering courses that are used to satisfy junior certification requirements. Included in this number are multiple repeats in a single class or single repeats in multiple classes. A warning will be issued in writing to students who

have accumulated two grades of D or F in UI mathematics, science, or engineering courses used to satisfy curricular requirements.

An average GPA of at least 2.0 is required for all chemical engineering courses used to satisfy the curricular requirements.

Materials Science and Engineering (B.S.M.S.E.)

Required course work includes the university requirements (see regulation J-3) and the following:

Chem 111	Principles of Chemistry I (4 cr)
Chem 112	Principles of Chemistry II (5 cr)
Chem 305	Physical Chemistry (3 cr)
Chem 307	Physical Chemistry Lab (1 cr)
Engl 317	Technical Writing (3 cr)
Engr 210	Engineering Statics (3 cr)
Engr 240	Introduction to Electrical Circuits (3 cr)
Engr 335	Engineering Fluid Mechanics (3 cr)
Engr 350	Engineering Mechanics of Materials (3 cr)
Math 170	Analytic Geometry and Calculus I (4 cr)
Math 175	Analytic Geometry and Calculus II (4 cr)
Math 275	Analytic Geometry and Calculus III (3 cr)
Math 310	Ordinary Differential Equations (3 cr)
MSE 101	Intro to Metallurgy and Materials Science (2 cr)
MSE 201	Elements of Materials Science (3 cr)
MSE 308	Thermodynamics of Materials (3 cr)
MSE 313	Physical Metallurgy (4 cr)
MSE 340	Transport and Rate Processes I (4 cr)
MSE 412	Mechanical Behavior of Materials (3 cr)
MSE 413	Phase Equilibria in Materials (3 cr)
MSE 417	Instrumental Analysis (3 cr)
MSE 423	Corrosion (3 cr)
MSE 427	Ceramic Materials (3 cr)
MSE 432	Fundamentals of Thin Film Fabrication (3 cr)
MSE 434	Fundamentals of Polymeric Materials (3 cr)
MSE 453	Process Analysis and Design I (3 cr)
MSE 454	Process Analysis and Design II (3 cr)
MSE 456	Metallic Materials (3 cr)
MSE 464	Materials Physics and Engineering (3 cr)
Phil 103	Ethics (3 cr)
Phys 211	Engineering Physics I (3 cr)
Phys 212, Phys 212L	Engineering Physics II and Lab (4 cr)
Stat 301	Probability and Statistics (3 cr)

Computer Science elective in a programming language (3 cr)
Economics Elective (3 cr)
Humanities and Social Science electives (6 cr)
MSE or ChE elective numbered 300 or greater (3 cr)
Technical electives in math, science, or engineering numbered 300 or greater (excluding any 398, 498, or 598 Internship) (3 cr)

Courses to total 127 credits for this degree, not counting Engl 101, any 398 (Internship), any 498 (Internship), any 598 (Internship),or mathematics courses numbered lower than Math 170, and other courses that might be required to remove deficiencies.

Students majoring in materials science engineering must earn a grade of C or better in each of the following courses before registration is permitted in upper-division materials science engineering courses: Chem 111 and Chem 112, Engr 210 and Engr 335, Math 275 and Math 310, MSE 201, and Phys 211 and Phys 212.

A passing grade is required in each of the following courses before registration is permitted in upper-division materials science engineering courses: computer science elective, Engl 102, Math 170 and Math 175, and MSE 101.

Any student majoring in materials science engineering may accumulate no more than four grades of D or F in UI mathematics, science, or engineering courses that are used to satisfy junior certification requirements. Included in this number are multiple repeats in a single class or single repeats in multiple classes. A warning will be issued in writing to students who have accumulated two grades of D or F in UI mathematics, science, or engineering courses used to satisfy curricular requirements.

An average GPA of at least 2.0 is required for all materials science engineering courses used to satisfy the curricular requirements.

Chemical and Materials Engineering Academic Minor Requirements

Materials Science and Engineering Minor

(Note: If completing both the Materials Science and Engineering major or minor and the Metallurgical Engineering minor, students must have 6 unique credits towards each minor)

MSE 201	Elements of Materials Science (3 cr)

And 17 cr from the following courses:

Engr 350	Engineering Mechanics of Materials (3 cr)
MSE 313	Physical Metallurgy I (4 cr)
MSE 340 or ChE 340	Transport and Rate Processes I (4 cr)
MSE 341	Particulate Materials Processing (4 cr)
MSE 412	Mechanical Behavior of Materials (3 cr)
MSE 423	Corrosion (3 cr)
MSE 427	Ceramic Materials (3 cr)
MSE 432	Fundamentals of Thin Film Fabrication (3 cr)
MSE 434	Fundamentals of Polymeric Materials (3 cr)
MSE 438	Fundamentals of Nuclear Materials (3 cr)
MSE 456	Metallic Materials (3 cr)
MSE 464	Materials Physics and Engineering (3 cr)
Phys 212	Engineering Physics II (3 cr)

Courses to total 20 credits for this minor

Metallurgical Engineering Minor

MSE 201	Elements of Materials Science (3 cr)
MSE 313	Physical Metallurgy (4 cr)
MSE 344	Low Temperature Processing of Materials (3 cr)
MSE 442	High Temperature Processing of Materials (3 cr)
MSE 456	Metallic Materials (3 cr)

And 6 cr from the following courses:

Engr 350	Engineering Mechanics of Materials (3 cr)
MSE 308	Thermodynamics of Materials (3 cr)
MSE 340 or ChE 340	Transport and Rate Processes I (4 cr)
MSE 341	Particulate Materials Processing (4 cr)
MSE 423	Corrosion (3 cr)
MSE 438 or NE 438	Fundamentals of Nuclear Materials (3 cr)
Phys 212	Engineering Physics II (3 cr)

Courses to total 20 credits for this minor

Chemical and Materials Engineering Graduate Academic Certificates Requirements

Advanced Materials Technology Graduate Academic Certificate

Note: A grade of 'B' or higher is required in all course work for this academic certificate.

Twelve credits from the following:

MSE 434	Fundamentals of Polymeric Materials (3 cr)
MSE 456	Metallic Materials (3 cr)
MSE 523	Corrosion (3 cr)
MSE 527	Ceramic Materials (3 cr)
MSE 538	Fundamentals of Nuclear Materials (3 cr)
MSE 564	Materials Physics and Engineering (3 cr)

Courses to total 12 credits for this certificate

Chemical and Materials Engineering Graduate Degree Programs

Candidates must fulfill the requirements of the College of Graduate Studies and of the Department of Chemical and Materials Engineering. See the College of Graduate Studies section for the general requirements applicable to each degree.

Master of Science. Majors are available in chemical engineering, materials science and engineering, and metallurgical engineering. General M.S.

requirements apply. All students entering the chemical engineering program must complete ChE 515, ChE 529, and ChE 541.

Master of Engineering. General M.Engr. requirements apply.

Doctor of Philosophy. Majors are available in chemical engineering and materials science and engineering While most students entering the graduate program possessing only the bachelor's degree will first earn the M.S., it is possible to bypass the M.S. and work directly toward the Ph.D. Students electing this option will be expected to critically analyze a current research area as part of their degree requirements. This will constitute their Ph.D. qualifying examination. For others, the oral M.S. thesis examination serves as the Ph.D. qualifying examination. A written research proposal modeled after those submitted to such agencies as the National Science Foundation is required as part of the requirements for the Ph.D.

CHEMICAL ENGINEERING COURSES

Wudneh Admassu, Dept. Chair, Dept. of Chemical and Materials Engineering (305 Buchanan Engr. Lab. 83844-1021; phone 208/885-8918).

ChE 110 Introduction to Chemical Engineering (1 cr)
Introduction to chemical engineering career opportunities and process principles including problem solving and documentation skills. Graded P/F.

ChE 123 Computations in Chemical Engineering (2 cr)
Methods of analyzing and solving problems in chemical engineering using personal computers; spreadsheet applications, data handling, data fitting, material balances, experimental measurements, separations, and equation solving. Coordinated lec-lab periods.
Prereq: *Min 520 SAT math or min 22 ACT math or 49 COMPASS Algebra or Math 143 or Math 170; or Permission*
Coreq: *Math 143, Math 170, or higher*

ChE 204 (s) Special Topics (cr arr)

ChE 210 Integrated Chemical Engineering Fundamentals (1 cr)
Recitation support for fundamental STEM courses and process principles including problem solving and documentation skills. Twice a week, 2 hour recitation sessions. Graded P/F.
Prereq: *ChE 110 and ChE 123*

ChE 223 Material and Energy Balances (3 cr)
Conservation of mass and energy calculations in chemical process systems.
Prereq: *Chem 112 and Math 175*

ChE 299 (s) Directed Study (cr arr)

ChE 307 Group Mentoring (1 cr, max 3)
Mentoring of student groups in engineering classes where a process education environment is used; students taking this course will improve their engineering skill in the area they are mentoring as well as improving their team, communication, and leadership skills. Students must attend all classes or labs where group activities in the process education environment are done (a minimum of 2 mentoring sessions per week).
Prereq: *Permission*

ChE 326 Chemical Engineering Thermodynamics (3 cr)
Behavior and property estimation for nonideal fluids; phase and reaction equilibria; applications to industrial chemical processes.
Prereq: *ChE 223, Engr 320 and 335, Math 310.* ***Coreq:*** *Chem 305.*

ChE 330 Separation Processes I (3 cr)
Equilibrium stagewise operations, including distillation, extraction, absorption.
Prereq: *ChE 326, Chem 305.*

ChE 340 Transport and Rate Processes I (4 cr)
Same as MSE 340. Transport phenomena involving momentum, energy, and mass with applications to process equipment design. Coordinated lec-lab periods.
Prereq: *Engr 335, Math 310, and ChE 223 or MSE 201*

ChE 341 Transport and Rate Processes II (4 cr)
Transport phenomena involving momentum, energy, and mass with applications to process equipment design. Coordinated lec-lab periods.
Prereq: *ChE 340*

ChE 393 Chemical Engineering Projects (1-3 cr, max 9)
Problems of a research or exploratory nature.
Prereq: *Permission of department*

ChE 398 (s) Engineering Cooperative Internship (3 cr)
Supervised internship in professional engineering settings, integrating academic study with work experience; requires written report; positions are assigned according to student's ability and interest. Graded P/F.
Prereq: *Permission*

ChE 404 (s) Special Topics (cr arr)
Prereq: *Permission*

ChE 415 Integrated Circuit Fabrication (3 cr)
Growth of semiconductor crystals, microlithography, and processing methods for integrated circuit fabrication. Recommended Preparation: ChE 223.

ChE 423 Reactor Kinetics and Design (3 cr)
Chemical reaction equilibria, rates, and kinetics; design of chemical and catalytic reactors.
Prereq: *ChE 223, Math 310, Chem 305*

ChE 433 Chemical Engineering Lab I (1 cr)
Senior lab experiments in chemical engineering.
Prereq: *ChE 330, 341, 423*

ChE 434 Chemical Engineering Lab II (1 cr)
Senior lab experiments in chemical engineering.
Prereq: *ChE 330, 341, 423*

ChE 444 Process Analysis and Control (3 cr)
Process modeling, dynamics, and analysis. Coordinated lecture-lab periods. Recommended Preparation: ChE 223, Math 310.

ChE 445 Digital Process Control (3 cr)
Same as ECE 477. Dynamic simulation of industrial processes and design of digital control systems. Coordinated lecture-lab periods. Recommended Preparation: ChE 444 (Recommended Preparation for EE majors: ECE 350).

ChE 451 Environmental Management and Design (cr arr)
Waste management application projects; projects require original design, working model, and report. May involve week-long trip to national competition. One lec and 3 hrs of lab a wk; weekly team status report meetings plus weekly task reviews with advisor.
Prereq: *Permission (by invitation only).*

ChE 452 Environmental Management and Design (cr arr)
Waste management application projects; projects require original design, working model, and report. May involve week-long trip to national competition. One lec and 3 hrs of lab a wk; weekly team status report meetings plus weekly task reviews with advisor.
Prereq: *Permission (by invitation only).*

ChE 453 Process Analysis and Design I (3 cr)
Same as MSE 453. Estimation of equipment and total plant costs, annual costs, profitability decisions, optimization; design of equipment, alternate process systems and economics, case studies of selected processes. ChE 453 and ChE 454/MSE 453 and MSE 454 are to be taken in sequence. (Fall only)
Prereq: *ChE 330, ChE 341, and ChE 423; or MSE 201, MSE 308, MSE 313, MSE 340, and MSE 412*

ChE 454 Process Analysis and Design II (3 cr)
Same as MSE 454. Estimation of equipment and total plant costs, annual costs, profitability decisions, optimization; design of equipment, alternate process systems and economics, case studies of selected processes. ChE 453 and 454 are to be taken in sequence. (Spring only)
Prereq: *ChE 453 or MSE 453*

ChE J460/J560 Biochemical Engineering (3 cr)
Application of chemical engineering to biological systems including fermentation processes, biochemical reactor design, and biological separation processes. Additional projects/assignments reqd for grad cr.

ChE J470/J570 Hazardous Waste Management (3 cr)
Principles and practices of management of hazardous and solid wastes with emphasis on CERCLA (Superfund) process for cleanup of uncontrolled hazardous waste sites and RCRA process as it applies to industrial waste treatment, storage, and disposal (TSD) facilities. Additional projects/assignments reqd for grad cr. Recommended Preparation: Stat 301.
Prereq: *Senior or Graduate standing in science or engineering, and Permission*

ChE J475/J575 Air Pollution Control (2-3 cr)
Analysis and design of physical and chemical methods of air pollution control; particulate and gas emission control methods, standards for

sources. Additional projects/assignments reqd for grad cr. Recommended Preparation: Engr 335.

ChE J480/J580 Engineering Risk Assessment for Hazardous Waste Evaluations (3 cr)
Quantitative and qualitative approaches to assessing risks to public health and environment from chemical contaminants; toxicology, exposure assessment, risk characterization, and environmental modeling; critical reviews of specific toxins and actual waste site studies. Additional projects/assignments reqd for grad cr. Recommended Preparation: Biol 100 or 201, Stat 301, and ChE 470.
Prereq: *Senior or Graduate standing in science or engineering*

ChE J490/J590 Hydrogen Energy Systems (3 cr)
Introduction to hydrogen economy; hydrogen production, storage and utilization; fuel cells; distribution, infrastructure, safety and environmental considerations. Additional projects/assignments reqd for grad cr.
Prereq: *Senior or Graduate standing in science or engineering*

ChE 491 (s) Seminar (1 cr)
Recent developments and topics. Graded P/F.
Prereq: *Senior standing*

ChE 499 (s) Directed Study (cr arr)

ChE 500 Master's Research and Thesis (cr arr)

ChE 501 (s) Seminar (cr arr)

ChE 502 (s) Directed Study (cr arr)

ChE 504 (s) Special Topics (cr arr)

ChE 515 Transport Phenomena (3 cr)
Same as ME 515. Advanced treatment of momentum, energy, and mass transport processes; solution techniques. Cooperative: open to WSU degree-seeking students.
Prereq: *B.S.Ch.E. and Equivalent of ChE 340, ChE 341 or Permission*

ChE 527 Thermodynamics (3 cr)
Thermodynamic laws for design and optimization of thermodynamic systems, equations of state, properties of ideal and real fluids and fluid mixtures, stability, phase equilibrium, chemical equilibrium, applications of thermodynamic principles. Cooperative: open to WSU degree-seeking students.
Prereq: *B.S.Ch.E. and Equivalent of ChE 326 or Permission*

ChE 529 Chemical Engineering Kinetics (3 cr)
Interpretation of kinetic data and design of reactors for heterogeneous chemical reaction systems; heterogeneous catalysis, gas-solid reactions, gas-liquid reactions; packed bed reactors, fluidized bed reactors. Cooperative: open to WSU degree-seeking students.
Prereq: *B.S.Ch.E. and Equivalent of ChE 423 or Permission*

ChE 536 Electrochemical Engineering (3 cr)
Application of chemical engineering principles to electrochemical systems; thermodynamics, kinetics, and mass transport in electrochemical systems; electrochemical process design. Recommended preparation: graduate engineering standing.

ChE 541 Chemical Engineering Analysis I (3 cr)
Mathematical analysis of chemical engineering operations and processes; mathematical modeling and computer applications. Cooperative: open to WSU degree-seeking students.
Prereq: *B.S.Ch.E. and Equivalent of ChE 444 or Permission*

ChE 545 Mass Transfer Operations I (3 cr)
Diffusional and equilibrium operations.
Prereq: *B.S.Ch.E. and equivalent of ChE 341 or Permission*

ChE 546 Mass Transfer Operations II (3 cr)
Diffusional and equilibrium operations.
Prereq: *B.S.Ch.E. and equivalent of ChE 341 or Permission*

ChE 560 Biochemical Engineering (3 cr)
See ChE J460/J560.

ChE 570 Hazardous Waste Management (3 cr)
See ChE J470/J570.

ChE 571 Advanced Plant Design (3 cr)
Design of process plants for optimum costs and economic return; scale-up of pilot plants.
Prereq: *B.S.Ch.E. and Equivalent of ChE 453 or Permission*

ChE 575 Air Pollution Control (2-3 cr)
See ChE J475/J575.

ChE 580 Engineering Risk Assessment for Hazardous Waste Evaluations (3 cr)
See ChE J480/J580.

ChE 581 Hazardous Waste Management Seminar (1 cr)
Environmental engineering and science topics related to hazardous waste characterization, cleanup, and regulations; includes case histories, paper, and oral presentation.
Prereq: *Permission*

ChE 590 Hydrogen Energy Systems (3 cr)
See ChE J490/J590.

ChE 600 Doctoral Research and Dissertation (cr arr)

MATERIALS SCIENCE AND ENGINEERING COURSES

Wudneh Admassu, Dept. Chair, Dept. of Chemical and Materials Engineering (203B McClure Hall. 83844-3024; phone 208/885-6376).

MSE 101 Introduction to Metallurgy and Materials Science (2 cr)
Earth resources, metallurgy, materials science, and manufacturing. (Fall only)

MSE 201 Elements of Materials Science (3 cr)
Principles relating properties of metals, ceramics, polymers, and composites to their structures.
Prereq: *Chem 111*

MSE 308 Thermodynamics of Materials (3 cr)
First, second, and third laws of thermodynamics. Reaction equilibria. Phase diagrams. Thermodynamics of metallic and ceramic materials.
Prereq: *MSE 201 and Chem 112*
Coreq: *Math 310*

MSE 313 Physical Metallurgy (4 cr)
Theory, structure, and properties of materials. (Fall only)
Prereq: *MSE 201*

MSE 340 Transport and Rate Processes I (4 cr)
See ChE 340.

MSE 341 Particulate Materials Processing (4 cr)
Engineering science of particulates; powder production, powder properties, separation; design of systems applied to metals, ores, and concentrates. Three lec and one hr of lab a wk; two 1-day field trips. Recommended Preparation: Phys 212, and Engr 240.
Prereq: *Chem 112*
Coreq: *Math 310*

MSE 344 Low Temperature Processing of Materials (3 cr)
Low temperature processing methods and objectives. Aqueous and non-aqueous (ionic liquids) processing systems. Solution thermodynamics. Solution purification and concentration methods. Synthesis of ceramic materials: electrolytic, precipitation, sol-gel methods. Thin film and bulk deposition methods. Surface preparation and deposition of discrete functional features (pillars, discs, dots). Electrochemistry in electronic chip interconnect technologies. Process design and analysis.
Prereq: *Chem 112 and MSE 201 or ChE 223; or Permission*

MSE 393 Materials Engineering Projects (1-3 cr, max 9)
Problems of a research exploratory nature.
Prereq: *Permission*

MSE 400 (s) Seminar (cr arr)

MSE 404 (s) Special Topics (cr arr)

MSE 412 Mechanical Behavior of Materials (3 cr)
Theories of elasticity and plasticity, dislocation based plastic deformation, strengthening mechanisms, mechanical properties of solids and relevant testing methods, failure processes and theories, fracture mechanics. Coordinated lecture-lab periods.
Prereq: *MSE 201 and Junior Standing; or Permission*

MSE J413/J513 Phase Transformation and Kinetics (3 cr)
Free energy minimization algorithms. Construction of phase diagrams for liquid and solid systems. Reaction kinetics in liquid and solid systems. Determination of reaction kinetics parameters (reaction order, activation energy, reaction rate constants, etc.). Coordinated lec-lab periods. Additional projects/assignments reqd for grad cr.
Prereq: *Chem 112*

MSE 415 Materials Selection and Design (3 cr)
Selection of materials for use in structural applications; consideration of environment, stress conditions, cost, and performance as guide to properties; optimization of choice of materials and fabrication methods; open-ended problems of real applications in various industries. Recommended Preparation: MSE 313 and MSE 456. (Spring only)
Prereq: *MSE 201 and Engr 350*

MSE 417 Instrumental Analysis (3 cr)
Principles and laboratory experiments in x-ray diffraction, scanning electron microscopy, transmission electron microscopy, thermal analysis, etc. (Fall only)
Prereq: *Junior/Senior standing in an engineering discipline*

MSE J421/J521 Light Metals (3 cr) WSU MSE 421
Principles behind the physical metallurgy of the light metals Al, Mg, Ti, Be; discussion of characteristics and applications of alloys based on these metals. Additional projects/assignments reqd for grad cr. Recommended Preparation: MSE 313. (Spring, Alt/yrs)

MSE J423/J523 Corrosion (3 cr)
Engineering aspects of corrosion and its control presented in ways of importance to a practicing engineer. Topics include corrosion economics, detecting and monitoring corrosion, regulations, specifications, safety. Emphasis on corrosion monitoring and corrosion fundamentals: chemical and electrochemical reactions; chemical and electrochemical equilibria-including Pourbaix diagrams; electrochemical kinetics. Selection and use of materials, from stainless steels to plastics. Failure analysis. Additional projects/assignments reqd for graduate credit. Coordinated lecture-lab periods.
Prereq: *Chem 112 and MSE 201 or ChE 223; or Permission*

MSE J427/J527 Ceramics Materials (3 cr)
Crystallography, ceramic crystal structures, phase diagrams, phase transformation; mechanical properties, thermal properties, electrical and magnetic properties. Additional projects/assignments reqd for graduate credit. Recommended Preparation: MSE 313.

MSE 432 Fundamentals of Thin Film Fabrication (3 cr)
Physical deposition, chemical deposition, post deposition process, film characterization, and film properties. (Spring only)
Prereq: *Senior standing or Permission*

MSE 434 Fundamentals of Polymeric Materials (3 cr)
Polymer structure/property relationships and engineering applications. Topics include: overview of polymer chemistry and physics as they inform structure and properties for real-world applications, including sustainability considerations. Coordinated lecture-lab periods.
Prereq: *Chem 111 and Chem 112*

MSE J437/J537 Radiation Effects on Materials (3 cr)
Same as NE J437/J537. Interactions between radiation and solids.
Prereq: *MSE 201 or Permission*

MSE J438/J538 Fundamentals of Nuclear Materials (3 cr)
Same as NE J438/J538. This course is designed for students who wish to learn about nuclear materials and fuels from a materials science viewpoint. Topics to be covered include crystal structure, diffusion, radiation damage processes etc. Students who wish to receive credit for the 500 level course are required to do term-projects and advanced problems. (Spring only)
Prereq: *MSE 201 or NE 450; or Permission*

MSE 442 High Temperature Processing of Materials (3 cr)
High temperature processing methods and objectives. Sintering theory and practices. Heat treatment of materials (air, molten salts). Novel high temperature treatment methods including plasma processing. High temperature processing of materials of importance to electronic (production of ultrapure materials; ceramics) and nuclear energy (high temperature corrosion resistant materials) industries. Smelting of non-ferrous materials; smelting of ferrous materials; furnaces; flowsheet design and analysis.
Prereq: *Chem 112 and MSE 201 or ChE 223; or Permission*

MSE 453 Process Analysis and Design I (3 cr)
See ChE 453.

MSE 454 Process Analysis and Design II (3 cr)
See ChE 454.

MSE 456 Metallic Materials (3 cr)
Processes for extracting metals; various classes of metallic alloys; casting, powder metallurgy, mechanical working, and joining of metals. Em-

phasis on understanding relationship of processing, structure and properties. Some lab demonstration of metal fabrication processes included.
Prereq: *MSE 313 or Permission*

MSE J464/J564 Materials Physics and Engineering (3 cr)
Same as Phys J464/J564. Materials for circuits, Magnetism and magnetic materials, Ferroelectric and piezoelectric materials, Semiconductors, Optical properties of semiconductor for optoelectronics, thermal properties, electron band theory, superconductivity. Additional projects/assignments required for graduate credit. (Spring only)
Prereq: *Senior standing in an Engineering or Physics major, or Phys 305 and Phys 321;or Permission*

MSE 498 (s) Internship (cr arr)

MSE 499 (s) Directed Study (cr arr)

MSE 500 Master's Research and Thesis (cr arr)

MSE 501 (s) Seminar (cr arr)

MSE 502 (s) Directed Study (cr arr)

MSE 504 (s) Special Topics (cr arr)

MSE 507 Microstructures and Defects (3 cr)
This course correlates microstructure and defects with mechanical, physical and chemical properties of engineering materials. The fundamental characteristics of point, line, surface and volume defects in crystals will be elucidated on an advanced level. The essential elements of microstructure and their role in engineering materials will be discussed.
Prereq: *Graduate standing or Permission*

MSE 511 Nuclear Degradation Mechanisms (3 cr)
Topics include various degradation mechanisms as applicable to nuclear structural components, including corrosion, creep, radiation damage etc.
Prereq: *Graduate standing or Permission*

MSE 512 Nuclear Components Inspection (3 cr)
This course will cover various non-destructive testing techniques to evaluate the environmental degradation of the nuclear structural components. Remnant life estimation of structural components exposed to fatigue, creep and stress corrosion cracking service conditions will be discussed.
Prereq: *Graduate standing or Permission*

MSE 513 Phase Transformation and Kinetics (3 cr)
See MSE J413/J513.

MSE 516 Magnetic Materials (3 cr)
Study of paramagnetic, superparamagnetic, diamagnetic, ferrimagnetic, ferromagnetic, antiferromagnetic, magnetic anistropy, magnetostriction and the effect of stress, magnetic domain and magnetization process, induced magnetic anisotropy, magnetic fine particles, magnetic thin film, magnetization dynamics, hard magnet, soft magnet, magnetic recording, magnetic head, magnetic media, magneto-optical recording. (Spring, Alt/yrs)

MSE 517 Reaction Kinetics (3 cr)
Application of absolute reaction rate theory; time and temperature dependence; kinetics of gas-solid reactions; kinetics of solid-solid reactions; corrosion, diffusion, and recrystallization.
Prereq: *Materials Science Engineering graduate student or Permission*

MSE 521 Light Metals (3 cr)
See MSE J421/J521.

MSE 523 Corrosion (3 cr)
See MSE J423/J523.

MSE 525 Electronic Materials (3 cr)
Study of major chemical and physical principles affecting properties of solid state engineering materials. Topics include bonding, carrier statistics, band-gap engineering, optical and transport properties, novel materials systems, characterization, magnetism, and comprehensive introduction to physics of solid state devices.
Prereq: *Materials Science Engineering graduate student or Permission*

MSE 527 Ceramic Materials (3 cr)
See MSE J427/J527.

MSE 537 Radiation Effects on Materials (3 cr)
See MSE J437/J537.

MSE 538 Fundamentals of Nuclear Materials (3 cr)
See MSE J438/J538.

MSE 539 Advanced Mechanics of Materials (3 cr)
See ME 539.

MSE R550 Nuclear Reactor Fuels (3 cr)
Selection of materials and design of nuclear fuels, light water reactor fuels, metal and oxide dispersed fuels, high temperature ceramic fuels.
Prereq: *Permission*

MSE 564 Materials Physics and Engineering (3 cr)
See MSE J464/J564.

MSE 598 (s) Internship (cr arr)

MSE 599 (s) Non-thesis Master's Research (cr arr)

MSE 600 Doctoral Research and Dissertation (cr arr)

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