CERAMIC ENGINEERING

The ceramic engineering program is offered under the department of materials science and engineering.

Ceramic engineers produce materials vital to many advanced and traditional technologies: electronic and optical assemblies, aerospace parts, biomedical components, nuclear components, high temperature, corrosion resistant assemblies, fuel cells, and electronic packaging. Ceramic engineers generally work with inorganic, nonmetallic materials processed at high temperatures. In the classroom, ceramic engineering students learn the relationships between engineering properties and the chemistry and structure of ceramic materials and go on to apply these scientific principles to the design of new formulations and manufacturing processes. If you are interested in the "why" behind material properties, ceramic engineering will definitely interest you.

Ceramic engineering usually appeals to those who have a strong interest in finding practical applications of the basic sciences, especially chemistry and physics, and can be described as one of the disciplines where 'science and engineering intersect'. Design occurs at the atomic or microstructural level of solid materials. The Missouri S&T department of ceramic engineering specializes in glass and optical materials, electronic materials, and high temperature materials, but the same scientific and engineering principles that are learned can be applied to the design of new materials for other applications, including biomaterials, high strength materials, materials for energy generation, etc.

Most ceramic engineering classes and laboratories are held in McNutt Hall, but other research laboratories on campus are available to our students. Equipment exists for X-ray investigation of materials, for detection of thermally induced changes in chemistry and structure, for high temperature processing, and for measuring a wide variety of electronic, optical, magnetic, mechanical and thermal properties. The Graduate Center for Materials Research makes additional research equipment available to ceramic engineers, including electron microscopes, optical, infrared, and X-ray spectrometers, thermal analyzers, and high temperature/controlled atmosphere furnaces. Students may broaden their experience by assisting faculty in research projects, either for academic credit or for pay.

Undergraduate student organizations are very active and participation in local and national activities is encouraged. Cooperative education and internships are available with companies and research agencies around the country. Additional information about the department is available at http://mse.mst.edu/.

Mission Statement

The department will train the future industrial and academic leaders in ceramic engineering by providing a comprehensive, forward-looking and broad-based curriculum, which emphasizes fundamental principles, practical applications, oral and written communication skills, and professional practice and ethics. The department is distinguished by a nationally recognized graduate program that emphasizes research of significance to the state of Missouri and the nation while providing a stimulating educational environment.

The program educational objectives of the ceramic engineering program:

- Our graduates will be valued contributors in the science, technology, and management of ceramic engineering
- Our graduates will serve their profession and society
- Our graduates will continually enhance their professional skills and educational background
- Our graduates will promote a diverse and inclusive professional culture that nurtures learning, innovation, and growth

The specific outcomes of the ceramic engineering program are:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. An ability to communicate effectively with a range of audiences
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies

Bachelor of Science Ceramic Engineering

For the bachelor of science degree in ceramic engineering a minimum of 128 credit hours is required. These requirements are in addition to credit received for algebra, trigonometry, and basic ROTC courses. A student must maintain an average of at least two grade points per credit hour in ceramic engineering.

Each student's program of study must contain a minimum of 18 credit hours of course work from the humanities and the social sciences areas and should be chosen according to the following rules:

1. All students are required to take one history course and one economics course. The history course is to be selected from HISTORY 1200, HISTORY 1300, HISTORY 1310, or POL SCI 1200. The economics course may be either ECON 1100 or ECON 1200.
2. Of the remaining hours, 12 credit hours must be taken in humanities or social sciences. These credit hours must be taken in humanities or social sciences and must meet requirements as specified under "Engineering Degree Requirements" published in the current undergraduate catalog.
3. Special topics, special problems courses and honors seminars are allowed only by petition to and approval by the student's department chair.

Freshman Year

First Semester	Credits	Second Semester	Credits
FR ENG 1100	1	MATH 1215 or 1221	4
CHEM 1310	4	CHEM 1320	3

CHEM 1319	1	PHYSICS 1135	4
MATH 1214 or 1211	4	H/SS Elective	3
ENGLISH 1120	3	MECH ENG 1720	3
H/SS Elective	3		
	16		**17**

Sophomore Year

First Semester	Credits	Second Semester	Credits
CER ENG 2110	3	CER ENG 2120	3
CER ENG 2315	2	CER ENG 2210	2
CER ENG 3230	3	CER ENG 2325	2
MATH 2222	4	MATH 3304[1]	3
PHYSICS 2135	4	H/SS Elective	3
		CIV ENG 2200	3
	16		**16**

Junior Year

First Semester	Credits	Second Semester	Credits
CER ENG 3315	2	CER ENG 3325	2
CER ENG 3220	3	CER ENG 3410	3
CIV ENG 2210	3	PHYSICS 2305	3
CER ENG 3210	3	H/SS Elective	3
H/SS Elective	3	Advanced Chemistry Elective[3]	3
Technical Elective[2]	2	CER ENG 4410	3
	16		**17**

Senior Year

First Semester	Credits	Second Semester	Credits
CER ENG 4096	3	CER ENG 4097	3
CER ENG 4310	3	CER ENG 4220	3
CER ENG 4250	3	CER ENG 4240	3
Technical Elective[2]	3	Statistics Elective[1]	3
H/SS Elective	3	Technical Elective[2]	3
	15		**15**

Total Credits: 128

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1 All ceramic engineering students must take MATH 3304 and one statistics course (3000-level or higher).

2 Technical electives must be selected from upper level engineering and science courses with the advisor's approval.

3 All ceramic engineering students must select an advanced chemistry elective with the advisor's approval. The courses that can be considered are CHEM 2210, CHEM 2310, CHEM 3410, CHEM 4310, CHEM 4810, or CHEM 3420.

Specific Degree Requirements

1. Total number of hours required for a degree in ceramic engineering is 128.
2. The assumption is made that a student admitted in the department has completed 34 hours credit towards graduation. The academic program of students transferring from colleges outside Missouri S&T will be decided on a case-by-case basis.

Richard K Brow, Curators Distinguished Professor
PHD Pennsylvania State University

Anthony Convertine, Roberta and G. Robert Couch Assistant Professor
PHD University of Southern Mississippi

Fatih Dogan, Professor
PHD Technical University of Berlin

Arezoo Emdadi, Assistant Professor
PHD Missouri University of Science and Technology

William G Fahrenholtz, Curators Distinguished Professor
PHD University of New Mexico

Gregory E Hilmas, Curators Distinguished Professor and Department Chair
PHD University of Michigan-Ann Arbor

Wayne Huebner, Professor
PHD University of Missouri-Rolla

Aditya Kumar, Associate Professor
PHD Ecole Polytechnique Federale de Lausanne (EPFL)

David Lipke, Assistant Professor
PHD Georgia Institute of Technology

Jeffrey D Smith, Professor
PHD University of Missouri-Rolla

Jeremy Lee Watts, Associate Research Professor
PHD Missouri S&T

Kelley Wilkerson, Assistant Teaching Professor
PHD Missouri University of Science and Technology

CER ENG 2002 Cooperative Training (IND 1.0-3.0)
On-the-job experience gained through cooperative education with industry, with credit arranged through departmental cooperative advisor. Grade received depends on quality of reports submitted at work supervisor's evaluation.

CER ENG 2110 Atomic Structure Of Crystalline Ceramics (LEC 3.0)
The crystal-chemical principles used to design and manufacture materials with specified properties are developed and applied to oxides, clays, silicates and other nonmetallic compounds.

CER ENG 2120 Introduction To Glass Science And Technology (LEC 3.0)
A study of the atomic-level structure of oxide glasses and the relationships between composition, properties and structure of glass-forming systems. Simple rate processes will be introduced to explain temperature-dependent properties. Prerequisite: "C" or better grade in Cer Eng 2110.

CER ENG 2210 Ceramics In The Modern World (LEC 2.0)
An introduction to traditional and modern applications of ceramics providing a broad overview of all aspects of current ceramic technology.

CER ENG 2315 Ceramic Materials Laboratory I-Characterization Of Materials (LAB 2.0)
Laboratory experience in collection, beneficiation, and characterization of ceramic raw materials; granulation, compaction, and sintering of particulate materials; and characterization at an introductory level. Standard laboratory practice including safety, report writing, and error analysis are also emphasized. Prerequisite: Sophomore standing.

CER ENG 2325 Ceramic Materials Laboratory II Glass And Ceramic Processing (LAB 2.0)
Laboratory experience in design, processing, and characterization of glasses and ceramics. Glasses are formulated, melted and characterized to correlate composition and properties. Clay-based ceramics are formulated to meet performance specifications, prepared by slip casting/extrusion, and fired. Prerequisite: "C" or better grade in Cer Eng 2315.

CER ENG 3001 Special Topics (LAB 0.0 and LEC 0.0)
This course is designed to give the department an opportunity to test a new course. Variable Title.

CER ENG 3110 Introduction to Biomedical Engineering (LEC 3.0)
This course will provide an introduction to the interdisciplinary field of biomedical engineering. The molecular, cellular, physiological and engineering principles that govern the field will be covered. Applications will include biomaterials, tissue engineering, biomechanics, bioimaging, bioinstrumentation, bio-nanotechnology and artificial organs. Prerequisite: Junior standing or above. (Co-listed with Bio Sci 3110 and Chem Eng 3210).

CER ENG 3210 Thermal Processes In Ceramics (LEC 3.0)
Considerations in rate controlled processes in the fabrication of ceramics, packing of powders, comminution and calcination, drying and firing of ceramic ware, polymorphic transformations, sintering, grain growth and hot pressing, relationships of fabrication techniques to physical properties.

CER ENG 3220 Phase Equilibria (LEC 3.0)
The study of unary, binary and ternary inorganic, phase equilibrium systems with examples for solving practical engineering problems. Prerequisite: A grade of "C" or better in Cer Eng 3230.

CER ENG 3230 Thermodynamics of Materials (LEC 3.0)
Basic thermodynamic concepts are applied to materials. Calculations involving enthalpy, entropy, and Gibbs' free energy are studied. Inter-relationships among properties are emphasized. Fundamental concepts of phase equilibira are presented. Prerequisite: "C" or better grade in either Met Eng 1210 or Chem 1320.

CER ENG 3240 Applied Glass Forming (LAB 1.0 and LEC 1.0)
Examines the properties and behavior of molten glass along with basic forming techniques, including off-hand shaping, molding and casting. Prerequisites: A grade of "C" or better in Cer Eng 2210.

CER ENG 3315 Ceramic Processing Lab I (LAB 2.0)
The first half of a two-semester sequence that gives students practical knowledge of the methods and techniques used in the fabrication of ceramics. Prerequisite: "C" or better grade in Cer Eng 2325.

CER ENG 3325 Ceramic Processing Lab II (LAB 2.0)
The second half of a two-semester sequence that gives students practical knowledge of the methods and techniques used in the fabrication of ceramics. Prerequisite: A grade of "C" or better in Cer Eng 2325.

CER ENG 3410 Characterization Of Inorganic Solids (LEC 3.0)
X-ray diffraction analysis is emphasized including lattice parameter determination, qualitative and quantitative analysis methods, and sources of error. In addition, the basic principles of other common characterization techniques including electron microscopy, thermal analysis, and energy dispersive spectroscopy are discussed. Prerequisite: "C" or better grade in either Cer Eng 2110 or Met Eng 2110 or a similar introductory course on structure of solids.

CER ENG 4000 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

CER ENG 4001 Special Topics (LAB 0.0 and LEC 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

CER ENG 4096 Materials Senior Design I (LEC 3.0)
Overview of the methods, approaches, and techniques required to execute materials related capstone senior design projects. Formation of teams, assignment of projects, review of department curriculum concepts and topics, and comprehensive project management skills needed to complete projects will be used as means to learn the design process. Prerequisites: Met Eng 3125 and Met Eng 2125, or Cer Eng 3315 with a "C" or better. (Co-listed with Met Eng 4096).

CER ENG 4097 Materials Senior Design II (LAB 3.0)
A continuation of the Materials Senior Design I. Students working in groups will complete a capstone design project including process and product simulation and/or fabrication, safety aspects, environmental impact and capital and operating economics. Prerequisite: "C" or better in either Cer Eng 4096 or Met Eng 4096. (Co-listed with Met Eng 4097).

CER ENG 4099 Undergraduate Research (IND 0.0-6.0)
Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six (6) credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

CER ENG 4220 Mechanical Properties Of Ceramics (LEC 3.0)
This course will treat the theory and testing practice related to design based on the mechanical properties of ceramics. Prerequisite: A grade of "C" or better in Civ Eng 2210.

CER ENG 4230 Introduction to Composite Materials (LEC 3.0)
The objective of this course is to provide students a foundational understanding of process-structure-property relationships in composite materials. Topics will include composite architecture, constituents, and interfaces, fabrication techniques, introduction to macromechanical analytical treatments such as classical lamination theory, and design criteria. Prerequisites: Senior standing and a grade of "C" or better in Civ Eng 2210 or equivalent.

CER ENG 4240 Electrical Properties Of Ceramics (LEC 3.0)
The application of ceramic chemistry and physics to the development and evaluation of electronic, dielectric, magnetic, and optical properties. Emphasis is placed on the relationships between properties and crystal structure, defects, grain boundary nature, and microstructure. Prerequisite: "C" or better in Physics 2305.

CER ENG 4250 Thermal Properties Of Ceramics (LEC 3.0)
This course will teach the crystal physics underlying heat capacity, internal energy, phonon and photon conduction, and thermal expansion. These properties will be used to rationalize the behavior of a wide variety of ceramic materials in severe thermal environments. Prerequisite: A grade of "C" or better in Cer Eng 3220.

CER ENG 4310 Ceramic Processing (LEC 3.0)
Rudimentary theory and practice of powder production, ceramic suspension rheology, forming methods, drying, sintering and grain growth. Relation of processing steps to densification and microstructure development. Prerequisite: Cer Eng 3210 and Senior standing.

CER ENG 4410 Introduction to Integrated Computational Materials Engineering (LAB 1.0 and LEC 2.0)
This course will provide an introduction to different computational tools for studying materials at different length scales. Several atomistic, microscale, and continuum models will be introduced and bridging between different modeling scales will be discussed. This course has a computational laboratory to build models and run simulations. Prerequisites: A grade of "C" or better in both Cer Eng 3230 and Math 3304, and in either Cer Eng 2110 or Met Eng 2110.

CER ENG 4510 International Engineering and Design (LEC 3.0)
A multi-disciplinary engineering course focused on sustainable design and technology transfer to developing countries. Course includes elements of traditional capstone design classes. Experiential learning through competitions and/or field work is a major component of the class. Prerequisites: Senior standing, instructor approval, Geo Eng 5211, Geo Eng 5247. (Co-listed with Geo Eng 5092 and Met Eng 4510).

CER ENG 5000 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

CER ENG 5001 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

CER ENG 5002 Cooperative Training (IND 1.0-3.0)
On-the-job experience gained through cooperative education with industry, with credit arranged through departmental cooperative advisor. Grade received depends on quality of reports submitted at work supervisor's evaluation.

CER ENG 5040 Oral Examination (IND 0.0)
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/ comprehensive examination (oral/ written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

CER ENG 5099 Research (IND 0.0-15)
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Consent of instructor required.

CER ENG 5115 X-Ray Diffraction Analysis (LAB 1.0 and LEC 2.0)
Theory and practical aspects of x-ray diffraction analysis are covered including diffraction theory, qualitative and quantitative analysis techniques, electronic databases, and operation of modern powder diffractometers. Students cannot receive credit for both Cer Eng 3417 and Cer Eng 5115. Prerequisite: Preceded or accompanied by Cer Eng 3410.

CER ENG 5220 Advanced Mechanical Properties of Ceramics (LAB 1.0 and LEC 3.0)
An advanced course to treat the theory and testing practice related to design based on the mechanical properties of ceramics. The course also includes a laboratory consisting of experiments for the characterization of the mechanical properties of ceramics. Prerequisites: Graduate standing.

CER ENG 5230 Glass Science And Engineering (LEC 3.0)
The development, manufacturing methods, applications, and properties of flat, fiber, container, chemical, and special purpose glasses. Composition/property relationships for glasses and nucleation-crystallization processes for glass-ceramics are also covered. Prerequisite: Consent of Instructor required.

CER ENG 5250 Refractories (LEC 3.0)
The manufacture, properties, uses, performance, and testing of basic, neutral and acid refractories. Prerequisite: Cer Eng 3230.

CER ENG 5260 Dielectric And Electrical Properties Of Oxides (LEC 3.0)
The processes occurring in inorganic materials under the influence of an electric field are considered from basic principles. Emphasis is placed on application to real systems. Prerequisite: "C" or better grade in Cer Eng 4210.

CER ENG 5310 Advanced Ceramic Processing (LEC 3.0)
Materials, processing and design of microelectronic ceramics are covered. Introduction to devices, triaxial ceramics, high aluminas, tape fabrication, metallizations, thick film processing and glass-to-metal seals. Prerequisites: Cer Eng 3210 and Cer Eng 3325.

CER ENG 5810 Principles Of Engineering Materials (LEC 3.0)
Examination of engineering materials with emphasis on selection and application of materials in industry. Particular attention is given to properties and applications of materials in extreme temperature and chemical environments. A discipline specific design project is required. (Not a technical elective for undergraduate metallurgy or ceramic majors) (Co-listed with Aero Eng 3877, Chem Eng 5300, Physics 4523, Met Eng 5810).
