Metallurgical and Materials Engineering

2015-2016

Degrees Offered

• Master of Engineering (Metallurgical and Materials Engineering)
• Master of Science (Metallurgical and Materials Engineering)
• Doctor of Philosophy (Metallurgical and Materials Engineering)

Program Description

The program of study for the Master or Doctor of Philosophy degrees in Metallurgical and Materials Engineering is selected by the student in consultation with her or his advisor, and with the approval of the Thesis Committee. The program can be tailored within the framework of the regulations of the Graduate School to match the student’s interests while maintaining the main theme of materials engineering and processing. There are three Areas of Specialization within the Department:

• Physical and Mechanical Metallurgy;
• Physicochemical Processing of Materials; and,
• Ceramic Engineering.

The Department is home to six research centers:

• Advanced Coatings and Surface Engineering Laboratory (ACSEL);
• Advanced Steel Processing and Products Research Center (ASPPRC);
• Center for Advanced Non Ferrous Structural Alloys (CANFSA);
• Center for Welding Joining, and Coatings Research (CWJCR);
• Colorado Center for Advanced Ceramics (CCAC); and,
• Kroll Institute for Extractive Metallurgy (KIEM).

The Nuclear Science and Engineering Center (NuSEC) also operates closely with the Department.

A Graduate Certificate is offered by each Department Center – the requirements for the Graduate Certificate are:

1. Be admitted to MME Graduate Certificate Program upon the recommendation of the MME Department.
2. Complete a total of 12 hours of course credits of which only 3 credit hours can be at the 400 level.

The specific courses to be taken are determined by the Graduate Advisor in the Department Center selected by the candidate. A cumulative grade point average of B or better must be maintained while completing these requirements.

Degree Program Requirements

The program requirements for the three graduate degrees offered by the Department are listed below:

Master of Engineering Degree

Requirements: A minimum total of 30.0 credit hours consisting of:

1. A minimum of 24.0 credit hours of approved course work and 6.0 hours of graduate research-credits listed under MTGN700.
2. Approval of all courses by the Engineering-Report Committee and the Department Head (Engineering-Report Committee consisting of 3 or more members, including the advisor and at least 2 additional members from the Metallurgical and Materials Engineering Department.)
3. Submittal and successful oral defense, before the Engineering-Report Committee, of an Engineering Report, which presents the results of a case study or an engineering development.

Restrictions:

1. Only three (3) credit hours of independent course work, e.g. MTGN599, may be applied toward the degree.
2. A maximum of nine (9) credit hours of approved 400-level course work may be applied toward the degree.
3. Courses taken to remove deficiencies may not be applied toward the degree.

The Master of Engineering Degree can be obtained as part of the combined undergraduate/graduate degree program. See "Combined Undergraduate/Graduate Degree Programs" section of the bulletin for more details.

Master of Science Degree

Requirements: A minimum total of 30.0 credit hours, consisting of:

1. A minimum of 18.0 credit hours of approved course work and a minimum of 6.0 hours of graduate research-credits listed under MTGN707.
2. Approval of all courses by the Thesis Committee and the Department Head. (Thesis Committee: consisting of 3 or more members, including the advisor and at least 1 additional member from the Metallurgical and Materials Engineering Department.)
3. Submittal and successful oral defense of a thesis before a Thesis Committee. The thesis must present the results of original scientific research or development.

Restrictions:

1. Only three (3) credit hours of independent course work, e.g. MTGN599, may be applied toward the degree.
2. A maximum of nine (9) credit hours of approved 400-level course work may be applied toward the degree.
3. Courses taken to remove deficiencies may not be applied toward the degree.

Doctor of Philosophy Degree

Requirements: A minimum total of 72.0 credit hours consisting of:

1. A minimum of 36.0 credit hours of approved course work and a minimum of 24.0 hours of research-credits (MTGN707). Credit hours previously earned for a Master's degree may be applied, subject to approval, toward the Doctoral degree provided that the Master's degree was in Metallurgical and Materials Engineering or a similar field. At least 21.0 credit hours of approved course work must be taken at the Colorado School of Mines.
2. All courses and any applicable Master's degree credit-hours must be approved by the Thesis Committee and the Department Head (Thesis Committee consisting of: 5 or more members, including the advisor,
at least 2 additional members from the Metallurgical and Materials Engineering Department, and at least 1 member from outside the Department.)


5. Presentation of a Progress Report on their Research Project to the Thesis Committee; this presentation is usually 6 months after successfully completing the Q.P. Examinations and no fewer than 6 weeks before the Defense of Thesis.

6. Submittal and successful oral-defense of a thesis before the Thesis Committee. The thesis must present the results of original scientific research or development.

Restrictions:

1. Only six (6) credit hours of independent course work, e.g. MTGN599, may be applied toward the degree.

2. A maximum of nine (9) credit hours of approved 400-level course work may be applied toward the degree.

3. Courses taken to remove deficiencies may not be applied toward the degree.

Prerequisites

The entering graduate-student in the Department of Metallurgical and Materials Engineering must have completed an undergraduate program equivalent to that required for the B.S. degree in: Metallurgical and Materials Engineering, Materials Science or a related field. This undergraduate program should have included a background in science fundamentals and engineering principles. A student, who possesses this background but has not taken specific undergraduate courses in Metallurgical and Materials Engineering, will be allowed to rectify these course deficiencies at the beginning of their program of study.

Fields of Research

Ceramic Research

- Ceramic processing
- Ceramic-metal composites
- Functional materials
- Ion implantation
- Modeling of ceramic processing
- Solid oxide fuel cell materials and membranes
- Transparent conducting oxides

Coatings Research

- Chemical vapor deposition
- Coating materials, films and applications
- Epitaxial growth
- Interfacial science
- Physical vapor deposition
- Surface mechanics
- Surface physics
- Tribology of thin films and coatings

Extractive and Mineral Processing Research

- Chemical and physical processing of materials
- Electrometallurgy
- Hydrometallurgy
- Mineral processing
- Pyrometallurgy
- Recycling and recovery of materials
- Thermal plasma processing

Nonferrous Research

- Aluminum alloys
- High entropy alloys
- Magnesium alloys
- Nonferrous structural alloys
- Shape memory alloys
- Superalloys
- Titanium alloys

Polymers and Biomaterials Research

- Advanced polymer membranes and thin films
- Biopolymers
- Bio-mimetic and bio-inspired materials engineering
- Calcium phosphate based ceramics
- Drug delivery
- Failure of medical devices
- Interfaces between materials and tissue
- Living/controlled polymerization
- Organic-inorganic hybrid materials
- Porous structured materials
- Self- and directed-assembly
- Structural medical alloys
- Tissue as a composite material

Steel Research

- Advanced high strength steels
- Advanced steel coatings
- Carburized steels
- Deformation behavior of steels
- Fatigue behavior of steels
- Microalloyed steels
- Nickel-based steels
- Quench and partitioned steels
- Plate steels
- Sheet steels

Welding and Joining Research

- Brazing of ultra wide gaps
- Explosive processing of materials
- Laser welding and processing
- Levitation for kinetics and surface tension evaluation
- Materials joining processes
- Pyrochemical kinetics studies using levitation
- Underwater and under oil welding
- Welding and joining science
- Welding rod development
- Welding stress management
- Weld metallurgy
- Weld wire development

**Nuclear Materials Research**
- Nuclear materials characterization
- Nuclear materials processing
- Nuclear materials properties

**Experimental Methods**
- 3D atom probe tomography
- Atomic force microscopy
- Computer modeling and simulation
- Electron microscopy
- Mathematical modeling of material processes
- Nanoindentation
- Non-destructive evaluation
- X-ray diffraction

**Other Research Areas**
- Combustion synthesis
- Corrosion science and engineering
- Failure analysis
- Mechanical metallurgy
- Phase transformation and mechanism of microstructural change
- Physical metallurgy
- Reactive metals properties
- Strengthening mechanisms
- Structure-property relationships

| MTGN505 | CRYSTALLOGRAPHY AND DIFFRACTION | 3.0 |
| MTGN511 | SPECIAL METALLURGICAL AND MATERIALS ENGINEERING PROBLEMS | 1-3 |
| MTGN512 | SPECIAL METALLURGICAL AND MATERIALS ENGINEERING PROBLEMS | 1-3 |
| MTGN514 | DEFECT CHEMISTRY AND TRANSPORT PROCESSES IN CERAMIC SYSTEMS | 3.0 |
| MTGN516 | MICROSTRUCTURE OF CERAMIC SYSTEMS | 3.0 |
| MTGN517 | REFRactories | 3.0 |
| MTGN518 | PHASE EQUILIBRIA IN CERAMIC SYSTEMS | 3.0 |
| MTGN523 | APPLIED SURFACE AND SOLUTION CHEMISTRY | 3.0 |
| MTGN526 | GEL SCIENCE AND TECHNOLOGY | 3.0 |
| MTGN527 | SOLID WASTE MINIMIZATION AND RECYCLING | 3.0 |
| MTGN528 | EXTRACTIVE METALLURGY OF COPPER, GOLD AND SILVER | 3.0 |
| MTGN529 | METALLURGICAL ENVIRONMENT | 3.0 |
| MTGN530 | ADVANCED IRON AND STEELMAKING | 3.0 |
| MTGN531 | THERMODYNAMICS OF METALLURGICAL AND MATERIALS PROCESSING | 3.0 |
| MTGN532 | PARTICULATE MATERIAL PROCESSING I - COMMINUTION AND PHYSICAL SEPARATIONS | 3.0 |
| MTGN533 | PARTICULATE MATERIAL PROCESSING II - APPLIED SEPARATIONS | 3.0 |
| MTGN534 | CASE STUDIES IN PROCESS DEVELOPMENT | 3.0 |
| MTGN535 | PYROMETALLURGICAL PROCESSES | 3.0 |
| MTGN536 | OPTIMIZATION AND CONTROL OF METALLURGICAL SYSTEMS | 3.0 |
| MTGN537 | ELECTROMETALLURGy | 3.0 |
| MTGN538 | HYDROMETALLURGy | 3.0 |
| MTGN539 | PRINCIPLES OF MATERIALS PROCESSING REACTOR DESIGN | 3.0 |
| MTGN541 | INTRODUCTORY PHYSICS OF METALS | 3.0 |
| MTGN542 | ALLOYING THEORY, STRUCTURE, AND PHASE STABILITY | 3.0 |
| MTGN543 | THEORY OF DISLOCATIONS | 3.0 |
| MTGN544 | FORGING AND DEFORMATION MODELING | 3.0 |
| MTGN545 | FATIGUE AND FRACTure | 3.0 |
| MTGN546 | CREep AND HIGH TEMPERATURE MATERIALS | 3.0 |
| MTGN547 | PHASE EQUILIBRIA IN MATERIALS SYSTEMS | 3.0 |
| MTGN548 | TRANSFORMATIONS IN METALS | 3.0 |
| MTGN549 | CURRENT DEVELOPMENTS IN FERROUS ALLOYS | 3.0 |
| MTGN550 | ADVANCED CORROSION ENGINEERING | 3.0 |
| MTGN552 | INORGANIC MATRIX COMPOSITES | 3.0 |
| MTGN553 | STRENGTHENING MECHANISMS | 3.0 |
| MTGN554 | OXIDATION OF METALS | 3.0 |
| MTGN555 | SOLID STATE THERMODYNAMICS | 3.0 |
| MTGN556 | TRANSPORT IN SOLIDS | 3.0 |
| MTGN557 | SOLIDIFICATION | 3.0 |
| MTGN560 | ANALYSIS OF METALLURGICAL FAILURES | 3.0 |
| MTGN561 | PHYSICAL METALLURGY OF ALLOYS FOR AEROSPACE | 3.0 |
| MTGN564 | ADVANCED FORGING AND FORMING | 3.0 |
| MTGN565 | MECHANICAL PROPERTIES OF CERAMICS AND COMPOSITES | 3.0 |
| MTGN569 | FUEL CELL SCIENCE AND TECHNOLOGY | 3.0 |
| MTGN570 | BIOCOMPATIBILITY OF MATERIALS | 3.0 |
| MTGN571 | METALLURGICAL AND MATERIALS ENGINEERING LABORATORY | 1-3 |
| MTGN572 | BIOMATERIALS | 3.0 |
| MTGN580 | ADVANCED WELDING METALLURGY | 3.0 |
| MTGN581 | WELDING HEAT SOURCES AND INTERACTIVE CONTROLS | 3.0 |
| MTGN582 | MECHANICAL PROPERTIES OF WELDED JOINTS | 3.0 |
| MTGN583 | PRINCIPLES OF NON-DESTRUCTIVE TESTING AND EVALUATION | 3.0 |
| MTGN584 | NON-FUSION JOINING PROCESSES | 3.0 |
| MTGN586 | DESIGN OF WELDED STRUCTURES AND ASSEMBLIES | 3.0 |
| MTGN587 | PHYSICAL PHENOMENA OF WELDING AND JOINING PROCESSES | 3.0 |
### METALLURGICAL AND MATERIALS ENGINEERING

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<tr>
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<th>Course Title</th>
<th>Credits</th>
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<td>SPECIAL TOPICS IN METALLURGICAL AND MATERIALS ENGINEERING</td>
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<td>INDEPENDENT STUDY</td>
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<td>ADVANCED TRANSMISSION ELECTRON MICROSCOPY</td>
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<td>VAPOR DEPOSITION PROCESSES</td>
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<td>MTGN697</td>
<td>MICROSTRUCTURAL EVOLUTION OF COATINGS AND THIN FILMS</td>
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<td>MTGN699</td>
<td>INDEPENDENT STUDY</td>
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<td>MTGN700</td>
<td>GRADUATE RESEARCH CREDIT: MASTER OF ENGINEERING</td>
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<td>MTGN707</td>
<td>GRADUATE THESIS / DISSERTATION RESEARCH CREDIT</td>
<td>1-15</td>
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</tbody>
</table>

### Professors

- Ivar E. Reimanis, Interim Department Head, Herman F. Coors Distinguished Professor of Ceramics
- Corby G. Anderson, Harrison Western Professor
- Michael J. Kaufman, Dean of CASE
- Stephen Liu, American Bureau of Shipping Endowed Chair Professor of Metallurgical and Materials Engineering
- Ryan O’Hayre
- John G. Speer, John Henry Moore Distinguished Professor of Metallurgical and Materials Engineering
- Patrick R. Taylor, George S. Ansell Distinguished Professor of Chemical Metallurgy
- Chester J. Van Tyne, Associate Department Head, FIERF Professor

### Associate Professors

- Kip O. Findley
- Brian Gorman
- Jeffrey C. King
- Steven W. Thompson

### Assistant Professors

- Geoff L. Brennecka
- Emmanuel De Moor

### Research Associate Professors

- Corinne E. Packard
- Vladan Stevanovic
- Zhenzhen Yu

### Teaching Associate Professors

- Gerald Bourne
- John P. Chandler

### Research Professors

- Richard K. Ahrenkikel
- Ivan Cornejo
- Hongjun Liang
- Stephen Midson
- William Sproul
- William (Grover) Coors
- Robert Field
- Terry Lowe
- D. (Erik) Spiller
- James C. Williams

### Research Associate Professors

- Robert Cryderman
- Carole Graas
- Jianhua Tong
- Edgar Vidal

### Research Assistant Professors

- David Diercks
- Judith C. Gomez
- Jianliang Lin
- Svitlana Pylpenko

### Professors Emeriti

- George S. Ansell, President Emeritus
- W. Rex Bull, Professor Emeritus
- Glen R. Edwards, University Professor Emeritus
- John P. Hager, University Professor Emeritus
- George Krauss, University Professor Emeritus
- Gerard P. Martins, Professor Emeritus
- David K. Matlock, University Professor Emeritus
- Brajendra Mishra
John J. Moore, Professor Emeritus

David L. Olson, University Professor Emeritus

Dennis W. Readey, University Professor Emeritus

**Associate Professors Emeriti**

Gerald L. DePoorter

Robert H. Frost