Metallurgical and Materials Engineering

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 3.0 hours of either a three credit hour research based Independent Study (MTGN599) or a designated design course (minimum of 3 credit hours) and graduate seminar enrollment during duration of program (up to a maximum of 1 credit hour).

2. The designated design courses include the following courses: MTGN414, MTGN445, MTGN450, MTGN461, MTGN464, MTGN466, MTGN475/477, MTGN549, MTGN564, MTGN560. Alternative courses can be substituted with approval from the advisor and department head.

Restrictions:

1. Only three (3) credit hours of independent course work, e.g. MTGN599, may be applied toward the degree.
2. A minimum 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 also be obtained as part of the combined undergraduate/graduate degree program. See the Physics section of the undergraduate 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-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 CRISTALLOGRAPHY AND DIFFRACTION 3.0
MTGN511 SPECIAL METALLURGICAL AND MATERIALS 1-3
ENGINEERING PROBLEMS
MTGN512 SPECIAL METALLURGICAL AND MATERIALS 1-3
ENGINEERING PROBLEMS
MTGN514 DEFECT CHEMISTRY AND TRANSPORT 3.0
PROCESSES IN CERAMIC SYSTEMS
MTGN516 MICROSTRUCTURE OF CERAMIC SYSTEMS 3.0
MTGN517 REFRACTORIES 3.0
MTGN518 PHASE EQUILIBRIA IN CERAMIC SYSTEMS 3.0
MTGN523 APPLIED SURFACE AND SOLUTION 3.0
CHEMISTRY
MTGN526 GEL SCIENCE AND TECHNOLOGY 3.0
MTGN527 SOLID WASTE MINIMIZATION AND RECYCLING 3.0
MTGN528 EXTRACTIVE METALLURGY OF COPPER, 3.0
GOLD AND SILVER
MTGN529 METALLURGICAL ENVIRONMENT 3.0
MTGN530 ADVANCED IRON AND STEELMAKING 3.0
MTGN531 THERMODYNAMICS OF METALLURGICAL 3.0
AND MATERIALS PROCESSING
MTGN532 PARTICULATE MATERIAL PROCESSING I - 3.0
COMMINUTION AND PHYSICAL SEPARATIONS
MTGN533 PARTICULATE MATERIAL PROCESSING II - 3.0
APPLIED SEPARATIONS
MTGN534 CASE STUDIES IN PROCESS DEVELOPMENT 3.0
MTGN535 PYROMETALLURGICAL PROCESSES 3.0
MTGN536 OPTIMIZATION AND CONTROL OF 3.0
METALLURGICAL SYSTEMS
MTGN537 ELECTROMETALLURGY 3.0
MTGN538 HYDROMETALLURGY 3.0
MTGN539 PRINCIPLES OF MATERIALS PROCESSING 3.0
REACTOR DESIGN
MTGN541 INTRODUCTORY PHYSICS OF METALS 3.0
MTGN542 ALLOYING THEORY, STRUCTURE, AND PHASE 3.0
STABILITY
MTGN543 THEORY OF DISLOCATIONS, AND PHASE 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 3.0
ALLOYS
MTGN550 ADVANCED CORROSION ENGINEERING 3.0
MTGN551 INORGANIC MATRIX COMPOSITES 3.0
MTGN552 STRENGTHENING MECHANISMS 3.0
MTGN553 OXIDATION OF METALS 3.0
MTGN554 SOLID STATE THERMODYNAMICS 3.0
MTGN555 TRANSPORT IN SOLIDS 3.0
MTGN556 SOLIDIFICATION 3.0
MTGN557 ANALYSIS OF METALLURGICAL FAILURES 3.0
MTGN558 PHYSICAL METALLURGY OF ALLOYS FOR 3.0
AEROSPACE
MTGN559 ADVANCED FORGING AND FORMING 3.0
MTGN560 MECHANICAL PROPERTIES OF CERAMICS 3.0
AND COMPOSITES
MTGN561 FUEL CELL SCIENCE AND TECHNOLOGY 3.0
MTGN562 BIOCOMPATIBILITY OF MATERIALS 3.0
MTGN563 METALLURGICAL AND MATERIALS 1-3
ENGINEERING LABORATORY
MTGN564 ADVANCED WELDING METALLURGY 3.0
MTGN565 WELDING HEAT SOURCES AND INTERACTIVE 3.0
MTGN566 PHYSICAL PHENOMENA OF WELDING AND 3.0
JOINING PROCESSES
MTGN567 MECHANICAL PROPERTIES OF WELDED 3.0
JOINTS
MTGN568 PRINCIPLES OF NON-DESTRUCTIVE TESTING 3.0
AND EVALUATION
MTGN569 NON-FUSION JOINING PROCESSES 3.0
MTGN570 DESIGN OF WELDED STRUCTURES AND 3.0
ASSEMBLIES
MTGN571 PHYSICAL PHENOMENA OF COATING 3.0
PROCESSSES
MTGN572 BIOMATERIALS 3.0
MTGN573 PHYSICAL PHENOMENA OF WELDING AND 3.0
JOINING PROCESSES
MTGN574 PHYSICAL PHENOMENA OF COATING 3.0
PROCESSSES
MTGN575 NUCLEAR MATERIALS SCIENCE AND 3.0
ENGINEERING
MTGN576 ADVANCED TRANSMISSION ELECTRON 2.0
MICROSCOPY
MTGN577 ADVANCED TRANSMISSION ELECTRON MICROSCOPY LABORATORY 1.0
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<td>VAPOR DEPOSITION PROCESSES</td>
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<td>MICROSTRUCTURAL EVOLUTION OF COATINGS AND THIN FILMS</td>
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<td>GRADUATE THESIS / DISSERTATION RESEARCH CREDIT</td>
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**Professors**

Angus Rockett, Department Head
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, Program Director of Material Science
Ivar E. Reimanis, Professor, Herman F. Coors Distinguished Professor of Ceramics
Sridhar Seetharaman
John G. Speer, John Henry Moore Distinguished Professor of Metallurgical and Materials Engineering
Patrick R. Taylor, George S. Ansell Distinguished Professor of Chemical Metallurgy

**Associate Professors**

Amy Clarke
Kip O. Findley
Brian Gorman
Jeffrey C. King
Corinne E. Packard
Steven W. Thompson

**Assistant Professors**

Geoff L. Brennecka
Kester Clarke, FIERF Professor
Emmanuel De Moor
Vladan Stevanovic
Zhenzhen Yu

**Teaching Professor**

Gerald Bourne, Assistant Department Head

**Research Professors**

Richard K. Ahrenkiel
William (Grover) Coors
Ivan Cornejo
Robert Field
Terry Lowe
Stephen Midson
Paul Queneau
D. (Erik) Spiller
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**Research Associate Professors**

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Brock O’Kelly
Edgar Vidal
Gary Zito

**Research Assistant Professors**

David Diercks
Judith C. Gomez
Michael Sanders

**Professors Emeriti**

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John P. Hager, University Professor Emeritus
George Krauss, University Professor Emeritus
Gerard P. Martins, Professor Emeritus
David K. Matlock, University Professor Emeritus
Brajendra Mishra, University Professor Emeritus
John J. Moore, Professor Emeritus
David L. Olson, University Professor Emeritus
Dennis W. Readey, University Professor Emeritus
Chester J. Van Tyne, Professor Emeritus

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