

# Metallurgical Engineering

College of Mines and Earth Sciences

University of Utah



## Undergraduate Program Handbook 2020-2021

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## Introduction

This guide is intended to help students understand the undergraduate program in Metallurgical Engineering at the University of Utah. This guide is a supplement to the *University of Utah General Catalog* or *Bulletin*, which remains the official document of the required program leading to a Bachelor of Science Degree in Metallurgical Engineering.

## Brief Overview of Metallurgical Engineering

Metallurgical Engineering involves the study, design, implementation, and improvement of processes that transform rocks and minerals into metal and mineral products that make our lives better. Metallurgical engineering students take courses in: *particle separation technology*, which focuses on particle separation, processing, and recycling, and includes particle characterization, comminution, size separation, flotation, coal preparation, remediation of nuclear materials, automatic control and process engineering of particles including metal powders, energy-related minerals, pigments, and ceramics; *chemical metallurgy*, which focuses on metal removal, processing, and recycling into a purified metal and includes heterogeneous reaction kinetics, transport phenomena, computer modeling, leaching, solution purification, ion exchange, solvent extraction, precipitation, roasting, reduction, smelting, ironmaking and steelmaking; and *physical metallurgy*, which focuses on metal casting, forming, joining, and metal property evaluation and optimization and includes phase transformations, powder metallurgy, metallography, functionally graded materials, composites, magnetic materials, thin film processing, fatigue, positron annihilation, rapid solidification, metal failure analysis, and corrosion. (For additional information, please see <http://www.mse.utah.edu/>.)

## Accreditation

The Metallurgical Engineering Program is accredited by The Engineering Accreditation Commission of ABET ([www.abet.org](http://www.abet.org)), 111 Market Place, Suite 1050, Baltimore, MD 21202-4012; Telephone: (410) 347-7700.

## Mission Statement

The mission of the Metallurgical Engineering program at the University of Utah is to create an environment through teaching, research, and service that:

1. allows training of metallurgical engineering undergraduate and graduate students with the broad technical knowledge, critical thinking abilities, communication skills, social consciousness, and integrity necessary to become outstanding engineers and scientists in industry and academia,
2. facilitates generation of new knowledge, and
3. provides supporting service through consulting or other avenues to industry, government and general public.

The central theme of the program is the study of all aspects of metallic materials, from their initial recovery and production through their development, manufacture, and use. The primary academic goals of the program include undergraduate and graduate education as well as research training of undergraduate and graduate students. The program strives to produce graduates with the necessary

breadth of technical skills in extraction, process and plant design, and development, characterization, and manufacture of all metallic materials and components, that will make them strong competitors in the job market created by the mining, metallurgical, materials, manufacturing, and electronics industries. The program offers exceptional opportunities for graduate students to undertake research in a wide range of fields at a level that extends the frontiers of knowledge.

## Program Educational Objectives

For the B.S degree in Metallurgical Engineering, the Program Educational Objectives are:

1. Graduates will be practicing professionals or engaged in graduate/advanced studies in metallurgical engineering or related areas.
2. Graduates will continue to expand their knowledge and capabilities and contribute effectively to their chosen profession and to society.
3. Graduates will demonstrate technical and interpersonal skills that promote success in their career.

## Student Outcomes

The following student outcomes of the curriculum are assessed in order to meet Metallurgical Engineering B.S. Degree Program Educational Objectives

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.
8. An ability to understand structure, properties, processing, and performance relationships.

## Financial Aid and Scholarship Information

The Department of Materials Science and Engineering offers a variety of scholarships. Students are encouraged to apply for these scholarships.

Students should submit applications through both the College of Engineering (<https://www.coe.utah.edu/students/current/scholarships/>) and the College of Mines and Earth Sciences (<https://cmes.utah.edu/students/financial-aid.php>). Students should also consider applying for other scholarships offered by professional societies, as well as general University of Utah scholarships. Student loans, grants, and need-based scholarships are also available through the financial aid office (<https://financialaid.utah.edu/types-of-aid/scholarships/checklist.php>).

## Career Opportunities

Metallurgical Engineers play a key role in the nation's well-being because of the importance of metals and minerals in modern society. The broad use of metals and mineral in our society leads to a wide array of job opportunities. Our graduates work for companies such as Lockheed-Martin, BHP Steel, Rio Tinto, Nucor Steel, Aker Kvaerner, Freeport McMoRan, Chevron, GSC Foundries, Westinghouse, US Nuclear Regulatory Commission, Boart Longyear, Barrick, 1M Flash Technologies, Williams International, Newmont Gold, IBM, National Semiconductor, MEMC Electronics, Fluor Daniel, Samsung, Parker Aerospace, Johnson Matthey, Idaho National Engineering and Environmental Laboratory, etc. The average starting salary for students graduating with a bachelor's degree in Metallurgical Engineering is approximately \$60,000/yr. Job placement for metallurgical engineers is typically near 100%.



## Important People You Should Know



Department Chair  
**Prof. Michael Simpson**  
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(Curriculum Chair)  
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Administrative  
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Executive Secretary  
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## Materials Science and Engineering Teaching Faculty



Faculty Member &  
Area of Specialization

**Jeff Bates**

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Polymers



Faculty Member &  
Area of Specialization

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Computational Polymers



**Darryl Butt**

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**Zak Fang**

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Metals for energy storage  
Powder metallurgy



**Michael Free**

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Hydrometallurgy  
Electrometallurgy



Faculty Member &  
Area of Specialization



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Physical metallurgy  
Magnetic materials



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Computational  
Electronic Materials



**Swomitra "Bobby"**

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Nano-technology  
Sensors



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Electronic Materials



**York Smith**

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Mineral Processing



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Particle Processing



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u

Nuclear Materials  
Molten Salts



**Hong Yong Sohn**

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Chemical metallurgy

Faculty Member &  
Area of Specialization



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Ceramics



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Nanotechnology/  
Electronic Materials

**Chen Wang**

Faculty Member &  
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Nanomaterials

## Undergraduate Metallurgical Engineering Course Descriptions

See also university catalog at <https://catalog.utah.edu/#/home>

**MET E 1630** - Introduction to Metallurgical Engineering Part 1 (particle & chemical processing)

Lecture, 3 Credits

Co-requisites: CHEM 1210 OR Equivalent.

Introduction to metallurgical processing fundamentals and applied technology that are to separate minerals and chemically process minerals to produce high purity metals as well as the application of these principles and technologies in areas such as biomedical devices and sensors, energy conversion and storage, and nuclear material processing.

**MET E 1640** – Introduction to Metals/ Metallurgical Engineering

Lecture & Laboratory, 3 Credits

Basic principles of chemical and physics applied to structure of materials, especially metals and alloys. Phase diagrams, physical and mechanical behavior of solids.

**MET E 2300** – Elements of Mechanics

Lecture, 2 Credits

Prerequisites: (MET E 1620 OR Equivalent) & MATH 1210.

This course is designed to introduce analytical techniques for simple mechanics problems and to advance students' capability for formulation and design of simple structures. During the course, the following concepts will be covered: two and three-dimensional force systems, the concept of equilibrium, analysis of trusses and frames, centroids, bending moment, shear diagrams, and thermal stresses.

**MET E 3070** - Statistical Methods in Earth Sciences and Engineering

Laboratory & Lecture, 3 Credits

Recommended Prerequisite: College Algebra.

Probability density functions, fundamental sampling distributions, one- and two-sample estimation problems. Selected examples from mining, geology, metallurgy, and meteorology will be used to illustrate statistical methods. Lab exercises will use examples from earth sciences and engineering.

Designation: Quantitative Reasoning (Statistics/Logic)

**MET E 3200** - Computational Methods in Metallurgical Engineering

Lecture, 3 Credits

Prerequisites: C or better in MET E 3610 Corequisites: C or better in MATH 2250

This course is about the use of modern computation methods and techniques in solving metallurgical engineering problems. Nowadays, in most cases, a necessary condition to become a competent engineer is to have a minimum level of knowledge of computers and their effective utilization. However, although computers can help the user to substantially improve their productivity, computers will never replace the need of understanding the fundamental principles of the problem being solved. The main goal of this course is to introduce you to some modern computer applications and computational methods for problem solving.

There are a number of computer software available, each with their own capabilities, specific applications, and limitations. The goal of this course is to give an introduction to some software packages and how to use them in solving metallurgical engineering problems.

**MET E 3610** - Metallurgical Thermodynamics I

Lecture, 3 Credits

Recommended Prerequisite: CHEM 1220 and MATH 1210.

Introduce the concepts and techniques required to make chemical/metallurgical process calcula-

tions and determine required inputs and outputs. Introduce the First, Second, and Third Laws of Thermodynamics and related concepts. Demonstrate techniques for making energy and combined mass-and-energy balances for a process.

Designation: Quantitative Intensive BS

### **MET E 3630 - Metallurgical Thermodynamics II**

Lecture, 3 Credits

Prerequisites: CHEM 1220, MATH 2250, AND METE 3610.

Continuation of *Metallurgical Thermodynamics I* in which changes in Gibb's free energy and chemical potential are used to work with phase and chemical reaction equilibrium problems. Covers single-phase equilibrium, multicomponent phase equilibrium, non-ideal gas equations of state, ideal and non-ideal solutions, chemical reactions involving gaseous and condensed phases, construction and interpretation of phase diagrams, electrochemistry, and equilibrium behavior of ionic solutions.

### **MET E 5260 - Physical Metallurgy I**

Lecture, 3 Credits

Recommended Prerequisite: MET E 1620.

Phase transformations in metals and alloys: Elementary physical chemistry of phases, phase diagrams and phase rule application, diffusion in solids, structure of interfaces, nucleation and growth, solidification, pearlitic, bainitic, massive and order-disorder transformations, precipitation, elementary treatment of martensitic transformation, iron-carbon system, and heat-treatment of steels. Laboratory sessions illustrate principles developed in lectures.

Designation: Quantitative Intensive BS

### **MET E 5450 - Mechanical Behavior of Metals**

Lecture, 3 Credits

Recommended Prerequisites: MET E 1620 and MET E 2300.

Stress and strain analysis, Mohr's circle, yield criteria, elastic and plastic deformation, deformation of single and polycrystals, dislocations, strengthening mechanisms, fatigue, creep and fracture of metals. Also involves a design problem of material selection for gas-turbine blades on the basis of mechanical property requirements.

Designation: Quantitative Intensive BS

### **MET E 5670 - Mineral Processing I**

Lecture & Laboratory, 3 Credits

Recommended Prerequisite: MATH 2250 and MET E 3500.

Laboratory fee assessed. One laboratory period. Particulate technology, particle size distribution, sizing methodology, size reduction and classification processes, solid-liquid separation methods, flotation, gravity separation, and magnetic separation.

Designation: Quantitative Intensive BS

### **MET E 5700 - Low Temperature Chemical Processing**

Lecture & Laboratory, 3 Credits

Recommended Prerequisite: MET E 3620.

Laboratory fee assessed. Laboratory sessions every other week. Thermodynamic and kinetic fundamentals of commercially important metal utilization, extraction, recovery, refining, and removal processes in aqueous media.

Designation: Quantitative Intensive BS

### **MET E 5710 - High-Temperature Chemical Processing**

Lecture & Laboratory, 4 Credits

Recommended Prerequisite: MET E 3620 OR Equivalent.

Laboratory fee assessed. One laboratory period. Fundamentals of commercially important nonferrous and ferrous pyrometallurgical extraction. Thermodynamics and kinetics of high-temperature processes.

**MET E 5760 - Process Design and Economics I**

Lecture, 4 Credits

Recommended Prerequisites: MG EN 5170 and MET E 5260 and 5670 and 5700 and 5710.

Metallurgical process synthesis, flow sheet development, and associated economic analysis.

**MET E 5780 - Metals Manufacturing Processes**

Lecture & Laboratory, 3 Credits

Recommended Prerequisites: MET E 1620, 5260, and 5450.

Primary and secondary metal-shaping processes: casting and solidification of metals, powder metallurgy, machining and joining of metals. Emphasis will be on process design. Laboratory illustrates principles developed in lecture.

Attribute: SUSC

**MET E 5055 - Microsystems Design and Characterization**

Lecture, 3 Credits

Prerequisite: ME EN 5050 and ECE 5211 OR MSE 5211 and upper division undergraduate status in engineering.

Third in a three-course series on microsystems engineering. This course generalizes microsystems design considerations with practical emphasis on MEMS and IC characterization/physical analysis. Two lectures, one lab per week, plus 1/2 hour lab lecture. Must also register for ME EN 6056 (0-credit lab with fees).

Cross-listed Course(s): ECE5225 - Microsystems Design and Characterization ME EN5055 - Microsystems Design and Characterization MSE5055 - Microsystems Design and Characterization

**MET E 5210 - Nuclear Materials: Processing, fabrication, use and disposal**

Lecture, 3 Credits

Prerequisite: Introductory level metallurgy or materials science course.

The course will provide an in-depth coverage of the metallurgy of the materials used in the nuclear reactor core, power generation, reprocessing, transport, and waste disposal systems.

**MET E 5240 - Principles and Practice of Transmission Electron Microscopy**

Lecture & Laboratory, 3 Credits

Prerequisite: Engineering/College Physics Course or permission of instructor.

The course will cover the basic principles of electron diffraction in materials and the operation of transmission electron microscope. Hands-on experience with preparation of samples of various materials and structures in a TEM will be provided in laboratory sessions to illustrate the principles and practice of various TEM techniques. The course will consist of 2 lecture sessions and 1 laboratory session per week.

**MET E 5270 - Powder Metallurgy**

Lecture & Laboratory, 3 Credits

Recommended Prerequisite: MET E 1620 and 5260.

Powder preparation, rapid-solidification processing principles, powder characterization, theory of compaction, sintering, full-density processing, powder metallurgy component design, compact characterization, application of powder metallurgy processing to structural, electrical, magnetic, and biomedical components. The laboratory sessions are an integral part of the course. Participation by students is mandatory. The credit hour for the laboratory portion is 1.0. Laboratory schedule and location will be determined during the semester.

**MET E 5280 - Magnetic Materials and Devices**

Lecture, 3 Credits

To provide an in-depth understanding of the magnetism, processing and characterization of magnetic materials, and structure property-performance relationships in magnetic materials used in a number of engineering devices/applications.

**MET E 5290 - Principles and Practice of Nanoscience and Technology**

Lecture, 3 Credits

Prerequisite: Introductory level metallurgy or materials science course.

The course will cover the principles of material behavior and synthesis at the nanoscale, and its application to a wide range of industrial and biotechnology applications. A historical development and an overview of the nanotechnology is first provided followed by treatment of the basic physics of behavior at the nanoscale.

This is followed by (i) synthesis of particle and structure at the nanoscale using vapor phase, physical vapor deposition, comminution and electrochemical approaches for use in metallurgical, pharmaceutical, cosmetic, medical, electronic, ceramic, agricultural, and other applications, (ii) processing and mechanical behavior of nano-scale structures, (iii) electrochemical synthesis and characterization in nanostructures including micro- and nanomachining, (iv) magnetism at the nano-scale and principles and fabrication of nano-scale magnetic devices, (v) biochemical processing, and (vi) Nanoscale characterization using AFM, STM, MFM, TEM and other techniques.

#### **MET E 5300 - Alloy and Material Design**

Lecture, 3 Credits

Prerequisites: MET E 5260 and MET E 5450.

Design of microstructure for control of materials properties, electronic structure and properties of metals, strengthening mechanisms, microstructural origins of strength in high-strength steels, aluminum and titanium alloys, microstructural factors controlling creep in structural alloys and composites, microstructure design of cements.

#### **MET E 5600 - Corrosion Fundamentals and Minimization**

Lecture, 3 Credits

Recommended Prerequisite: CHEM 1220.

Basic principles of corrosion, including forms and mechanisms of corrosion; corrosion evaluation using electrochemical, microscopic, and

other tools; minimization theory, prediction, practice, and economic assessment.

#### **MET E 5610 - Proton Exchange Membrane Fuel Cells**

Lecture, 3 Credits

Prerequisite: MET E 3620, CH EN 3853 or equivalent.

Fuel cells hold the promise of providing clean energy for many applications. In this course, the theory, practice technology of proton exchange membrane fuel cells will be presented. Topics to be covered are fuel cell electrochemistry, thermodynamics and mass transfer and cell design, construction and operations. Additionally, stack and system design will be discussed for various applications.

#### **MET E 5660 - Surfaces & Interfaces**

Lecture, 2 Credits

Recommended Prerequisites: MET E 3620 and CHEM 3060.

Capillarity, films on liquids, Gibbs adsorption, surface spectroscopy, electrical phenomena at interfaces, solid surfaces, wetting, nucleation.

#### **MET E 5765 - Process Design and Economics II**

Lecture, 3 credits

Recommended Prerequisites: MG EN 5170 or (MET E 5260 AND 5670 AND 5700 AND 5710) OR equivalent.

Metallurgical process synthesis, flow sheet development, and associated economic analysis.

#### **MET E 5770 - Electrometallurgy Lecture**

Lecture, 2 Credits

Recommended Prerequisite: MET E 3620.

Principles of electrodeposition and electro-winning, including modern practices.

#### **MET E 5790 - Metal Failure Analysis**

Lecture, 2 Credits

Recommended Prerequisite: MET E 1620.

Metal-failure analysis, metal-failure modes. Methods and procedures of analysis.



### **MET E 5800** - Special Topics in Metallurgical Engineering

Special Topics, 3-5 Credits

Total Completions Allowed: 99.

Total Credit Allowed: 999.

### **MET E 5830** - Senior Project

Special Projects, 3-5 Credits

Total Completions Allowed: 99.

Total Credits Allowed: 999.

Senior students investigate research or design problem and submit report or thesis.

### **MET E 5910** - Selected Topics

Special Topics, 1-4 Credits

Total Completions Allowed: 99.

Total Credit Allowed: 999.

Lectures or seminars on topics of current interest.

### **MSE 1800** - Contemporary Materials Science and Engineering

Lecture, 1 Credit

Recommended Prerequisites: None

Introduces the student to materials science and engineering, including contemporary materials issues facing practicing engineers and scientists. This is accomplished through an introduction to the classification of materials and through speakers who work as materials scientists and engineers in industry.

### **MSE 1801** - Contemporary Materials Science and Engineering

Lecture, 1 Credit

Recommended Prerequisites: None

MSE 1801 is a continuation of MSE 1800 with further emphasis on learning about the field of materials. Based on the material taught in MSE 1800, students will focus on a materials science and engineering research project culminating in a written paper and an oral presentation.

Additionally, we will introduce students to scientific computing. Students will learn communication skills, teamwork skills, and use critical thinking.

### **MSE 2001** - Programming for Materials Science & Engineering

Lecture, 1.5 Credits

Recommended Prerequisites:

This is a half semester course designed to teach students how to solve engineering problems through the application of programming principles using the Python 3 language. Students will be presented with fundamental programming knowledge that can serve as a foundation for future learning. During this course student will develop proficiency in the essentials of coding which includes: data representation, functions, logic, and control structures as they tackle a variety of common engineering questions.

### **MSE 2010** - Elements of Materials Science & Engineering

Lecture, 4 Credits

Recommended Prerequisites:

This is an introduction course for Materials Science and Engineering undergraduate students and Biomedical Engineering undergraduate students emphasizing in Biomaterials. The course teaches the fundamental of how to predict the properties of materials based on microstructure. The students will be able to: 1) understand how atomic bonding is related to modulus, melting point, and thermal expansion, 2) differentiate between amorphous and crystalline materials on the basis of x-ray diffraction and crystallinity, 3) predict diffusion in solids and understand how this is thermally activated, 4) understand how thermodynamics and kinetics combine to control the processing of advanced materials, 5) apply thermodynamics in understanding phase equilibria, 6) gain a basic understanding of what controls the electrical, optical, and thermal behavior of materials, and 7) be able to

understand fundamental design considerations for materials selection. Laboratory experiments will illustrate these principles including work hardening, brittle fracture, and phase transformation. Laboratory safety, methods of

literature search, data representation, elementary statistical analysis of data, routine property measurements, and report writing are emphasized.

## Technical Emphasis Options

### Biomedical Devices and Sensors Emphasis

Metals are used in a wide variety of high-tech devices such as those that replace essential human physiology functions, such as heart valves, artificial hips, pace makers, etc. Understanding the durability and biocompatibility of these devices relies upon fundamental metallurgical engineering subjects such as corrosion, surface chemistry, physical metallurgy, and strengths of metals. This emphasis gives students an advanced understanding of these applications and how to apply knowledge gained from their core curriculum to prepare students for careers in such high technology fields.

Required for BD&S Emphasis	Two of the Following Courses
MET E 5520 Biomedical Devices and Sensors MET E 5600 Corrosion MET E 5690 Process Engineering Statistics	MET E 5320 Materials and Environment MET E 5770 Electrometallurgy MSE 5040 Intro to Modern Biomaterials BIOEN 1020 Fund. of Bioengineering

### Chemical Processing Emphasis

Extraction of metals from minerals or waste materials and subsequent purification requires a fundamental understanding of chemical processes and principles. Students who pursue this emphasis will strengthen their education in chemical processing to support pursuit of careers in metals recycling, purification, and extraction. Completing this emphasis should give the student the educational background to pursue career opportunities also open to chemical engineers and extractive metallurgists.

Required for Chemical Processing Emphasis	Three of the Following Courses
MET E 5600 Corrosion <i>OR</i> MET E 5770 Electrometallurgy	CHEM 2310 Organic Chemistry CHEM 3100 Inorganic Chemistry CH EN 3353 Fluid Mechanics
MET E 5765 Process Design and Economics II <i>OR</i> MET E 5690 Proc. Eng. Statistics	MET E 5210 Nuclear Materials MET E 5330 Renewable Energy Conversion & Storage MET E 5520 Biomedical Devices and Sensors MET E 5800 Molten Salt Engineering

### Energy Conversion and Storage Emphasis

This emphasis provides in-depth instruction on the application of metallurgical engineering fundamentals to advanced energy production and storage systems-including renewable energy and nuclear energy. Students will learn about types of metals needed for these systems and requirements for developing advanced metal alloys to improve energy conversion and storage efficiency.

Required for EC&S Emphasis	Three of the Following Courses
MET E 5330 Renewable Energy Conversion & Storage	MET E 5320 Materials and Environment MET E 5600 Corrosion MET E 5690 Proc. Eng. Statistics MET E 5210 Nuclear Materials NUCL 3000 Nuclear Princ. In Eng. Sci. MSE 3210 Electronic Prop. Of Solids
MSE 5074 Photovolt. Materials & Solar Cells <i>OR</i> MET E 5770 Electrometallurgy	

### Mineral/Particle Processing Emphasis

Mineral processing is the study of practical methods for concentrating methods from ores. It teaches methods such as comminution/grinding, flotation, gravity separation, sorting, and dewatering. This field serves as a bridge between mining engineering and metallurgical engineering. Students who study this emphasis will be particularly well qualified to pursue careers and the mining industry.

Required for Mineral Processing Emphasis	Three of the Following Courses
MET E 5680 Mineral Processing II MET E 5765 Process Design & Economics II	MET E 5320 Materials and Environment MET E 5690 Process Engineering Statistics MET E 5800 Image Analysis MG EN 3010 Intro to Mining GEO 3070 Mineralogy and Petrology for Eng. CH EN 3353 Fluid Mechanics

### Nuclear Emphasis

Metals play a huge role in nuclear energy systems, making up the fuels, structural materials, and even coolants. Selection of optimal metals for nuclear energy systems requires understanding of physical properties, neutron interaction parameters, corrosion properties, cost, and fabricability. This is an ideal emphasis for a metallurgical engineering student wishing to pursue a graduate degree in nuclear engineering or pursue a career related to nuclear energy, nuclear waste, or research into advanced nuclear systems and processes.

Required for Nuclear Emphasis	Two of the Following Courses
MET E 5210 Nuclear Materials MET E 5600 Corrosion	ENVST 3368 Energy Choices or the 21st Century MET E 5690 Process Engineering Statistics MET E 5770 Electrometallurgy MET E 5800 Molten Salt Engineering MET E 5800 Amorphous Materials NUCL 3200 Radiochemistry
MET E 5800 Nuclear Safeguards <i>OR</i> NUCL 3000 Nuclear Principles	

### Physical Metallurgy Emphasis

Physical metallurgy is the study of the physical properties and processing methods for metals and alloys-including strength/hardness, microscopic structure, and phase properties. It studies the effect of both metal composition and processing methods on these properties. Alloy design is an important element of physical metallurgy that results in entirely new metals with targeted properties. Material characterization skills are key elements of the physical metallurgy emphasis. Students who study this emphasis can pursue careers in a wide range of industries in which metal properties are key for success of the products.

Required for Emphasis	Three of the Following Courses
MET E 5270 Powder Metallurgy <i>OR</i> MET E 5300 Alloy and Material Design	MET E 5320 Materials and Environment MET E 5330 Renewable Energy Conversion & Storage MET E 5520 Biomedical Devices & Sensors MET E 5600 Corrosion MET E 5690 Process Engineering Statistics MET E 5800 Magnetic Materials MET E 5800 Amorphous Materials MET E 5800 Solid state Thermodynamics MET E 5800 Image Analysis ME EN 2650 Manufacturing for Engineering Systems MSE 3210 Electronic Properties of Solids
MET E 5460 Advanced Characterization <i>OR</i> MSE 3011 Materials Characterization	

## Advising Information

Finishing MATH 1210 and 1220 during the first year is very important for students desiring to complete a B. S. degree in metallurgical engineering in four years. The University of Utah requires a recent (within two years) ACT, SAT, Accuplacer, or AP/IB Calculus exam score, or a recent concurrent enrollment (college-level course) grade to evaluate your math proficiency before deciding which math course you are allowed to take. Transfer students can satisfy prerequisites with transfer math classes. If you have not had a math course or placement test within two years, you will be required to take the Accuplacer exam.

If taking the Accuplacer exam, make sure you prepare well because your score determines your placement. Free practice exams are often available on the web through simple search engine queries. The Math department's math boot camps (MATH 10 and MATH 15) are accelerated review courses sometimes offered in one-week sessions. There are on-line prep tools such as ALEKS for a fee. The additional resources are particularly helpful for those who have not had a recent math course. For study resources and current information regarding math placement, please see the Math Department's website <http://www.math.utah.edu/> or contact that METE Academic Advisor.

Students who will take a leave of absence or are nontraditional/part-time should consider their math course schedules carefully. The Math Department has indicated that if students take MATH 1210 or higher before taking a leave of absence, it is generally easy to receive instructor approval to continue with the next math course, provided the previous grade was good, and it has not been more than three or four years since taking the previous course. In contrast, if students complete only a lower-level math course such as MATH 1050 before a leave of absence, they will be required to pass the Accuplacer exam at a sufficient level before registering for the next math class upon returning.

### Math Placement Guide

Math ACT Score(s)	Math SAT Score(s)	Accuplacer Scores*	Course Placement
17 or lower	420 or lower	AR < 120 or EA < 54	Math 990 Elementary Algebra
18-22	430-530	54 ≤ EA or CLM < 50	Math 1010 Intermediate Algebra**
23-27	540-620	CLM ≥ 50	Math 1030 Quantitative Reasoning Math 1040 Statistics & Probability Math 1070 Statistical Inference
		CLM ≥ 60	Math 1050 College Algebra Math 1060 Trigonometry
24-27	58-620	CLM ≥ 65	Math 1080 Precalculus
28 or higher	630 or higher	CLM ≥ 80	Math 1100 Quantitative Analysis
		90 ≤ CLM ≤ 94***	Math 1210 Calculus I
		95 ≤ CLM ≤ 120	Math 1310 Engineering Calculus I

\*AR = Arithmetic Test. EA = Elementary Algebra Test. CLM = College Level Math Test.

\*\*If a student places into Math 1100, the student should take both Math 1050 and 1060 instead of 1100, since 1050 and 1060 are the prerequisites for Math 1210.

\*\*\*Permission code required.

## Chemical Placement

Placement in CHEM 1210 General Chemistry I requires one of the following: Accuplacer CLM of 75+, Math ACT of 25+, Math SAT of 600+, or AP Calc AB/BC of at least 2.

## Technical Electives

Generally, technical electives are advanced courses that will build a stronger technical background for the future engineer. Upper-division courses (3000-level or above) offered in the Colleges of Engineering, Mines and Earth Sciences, and Science, that do not duplicate other required courses, are generally appropriate. The following are some pre-approved technical electives:

CH EN 3453, 3553, 3603	MET E 3080, 5210, 5270, 5600, 5290, 5640,
CHEM 3000, 3070	5610, 5660, 5770, 5790, 5800, 5910
GEO 3030	MG EN 5020, 5030, 5070, 5080, 5340
MSE 3210, 3310, 3410, 5010, 5035	WRTG 3014 (recommended as one technical elective)
MATH 5610	

Other courses may also be acceptable — please contact the departmental advisor for additional courses.

## Course Schedules/Registration Information

The current class schedule can be accessed through the web (<http://www.utah.edu/students/catalog.php>), at the Olpin Union Service Desk (no charge with valid student ID), or by contacting the Scheduling Office at 201 S 1460 E Room 40, University of Utah, Salt Lake City UT 84112-9056.

## Grades and Repeating Courses

Students must receive a grade of C– or better in each of the required major courses. Students are allowed to repeat required courses one time only. To repeat more than once and have the course count towards your requirements, you must submit a petition (see [https://mse.utah.edu/materials-science-engineering/bs-program-of-study/> Policies > Repeating Courses](https://mse.utah.edu/materials-science-engineering/bs-program-of-study/>Policies>Repeating%20Courses)) to the department and meet with the undergraduate advisor.

## Other University Requirements

Please see the Overview of Requirements and the *University of Utah Bulletin* (<http://undergradbulletin.utah.edu/>) for general requirements.

## Transfer Credit

Transfer credit will be granted for a course(s) taken at another accredited institution so long as a grade of C– or better was received and the course content was equivalent to the content of a corresponding required course in the Metallurgical



Engineering curriculum. The grade will not transfer. Transfer credits must be approved by the department.

### AP Credit

Please refer to the AP Placement Guide, page 12, or contact the department advisor.

### CLEP Credit

College credit may also be obtained by passing College Level Entrance Placement (CLEP) tests to fulfill certain general education requirements. Please contact the Academic Advising office for additional information (450 SSB – (801) 581-8146).

## Policy for Internship Technical Elective Credit

Students may earn 0.5 to 2 semester hours of technical elective credit for internship-related work experiences in industry or research labs, provided that the following criteria are met:

1. The student must be mentored by a company engineer.
2. The student must be primarily involved in testing/data analysis or process improvement/development activities where the student has the opportunity to practice and develop engineering skills.
3. The company must send in writing: a) verification that the student was involved in appropriate engineering activities; b) confirmation that the student was mentored by an engineer; and c) a general evaluation of the student's performance.
4. The student must register for Special Topics credit during the internship.
5. The student must write and submit a final report of 10 to 30 double-spaced pages, depending upon desired credit, that includes:
  - a. Literature Survey of General Project Topic(s)
  - b. Experimental Information
  - c. Data Presentation and Analysis
  - d. Project(s) Conclusions

Students need to include some data they have acquired as well as an analysis of their data as it relates to their project. However, students should omit proprietary details. Terms like process A or compound X should be used to protect sensitive company information. The report should not be submitted to the department until the company has had the opportunity to review it.

6. The student may be required to make an oral presentation in addition to writing the report.

*The course credit will be determined based upon the duration of the internship and the extent of the report. A final grade will be given based upon the final report and the company evaluation of the student's performance.*

## Faculty Mentoring Program for Undergraduate Students

The Department of Materials Science & Engineering offers a mentoring program for undergraduate students—including those majoring metallurgical engineering. Each student will be assigned to a specific faculty member, who will serve as mentor for various academic issues as needed by the student. Some of the functions of this mentor/student relationship include but are not limited to the following.

- Recommendations regarding selection of technical electives
- Advice regarding career and internship options
- Advice regarding extracurricular professional-related activities and attendance at technical society meetings
- Discussion of academic performance difficulties and potential remediation options

The purpose of having an official program is to guide undergraduate students towards the appropriate individuals in the department to provide the best possible assistance. Functions that will continue to be served by the Undergraduate Advisor, Brenda Wicks, include the following.

- Questions about degree requirements
- Obtaining permission codes for courses and requests for exceptions/substitutions
- New student orientation
- Mandatory advising (MAPS) as required during orientation, freshman year, and sophomore year
- Transferring credits
- Verifying enrollment for external entities

There is no requirement that students meet with their faculty mentors. The mentors are assigned to serve as a supplemental resource for the students. Students should initiate any requested meetings by contacting the faculty member via phone, e-mail, or personal contact. Appointments are encouraged, as the faculty are not expected to have open office hours for advising. E-mail contact should be made to either Ms. Wicks or the assigned faculty mentor via your UMail account.

Any student may request a change in their mentor, but such changes will be reviewed by the Department Chair before being approved. A request should be submitted in writing via e-mail or letter to Prof. Michael Simpson ([michael.simpson@utah.edu](mailto:michael.simpson@utah.edu)). The request should include a reason for the requested change, which will be handled confidentially. No faculty other than the Department Chair will be privy to these requests.

## Related Professional Societies with Student Membership

Students are encouraged to participate in professional societies as both members and leaders. Professional societies provide valuable opportunities for leadership, service, social interaction, and industrial exposure. Societies with active student chapters in the metallurgical engineering area include Material Advantage and Institute of Nuclear Material Management.

Please visit the Department of Materials Science and Engineering in CME 304 for additional information about membership in these societies including current contact information.

## Overview of Bachelor Degree Requirements

To earn a bachelor's degree from the University of Utah you must complete the following requirements and meet minimum academic standards.

IMPORTANT NOTE: The minimum grades are noted for each requirement. However, if a course is also required for your major it MUST be taken for the letter grade and a higher grade may be required.

### Academic Standards

#### *Total Semester Credit Hours*

A minimum of 122 semester credit hours is required for a bachelor's degree.

#### *Upper Division Credit Hours*

At least 40 of the required 122 semester hours must be at the 3000 level or above. Credits from 2-year schools will not count toward upper division hours.

#### *Residency Hours*

A minimum of 30 semester hours must be completed at the University of Utah.

20 of the last 30 semester hours must be completed at the University of Utah.

Telecourses, online courses and courses at satellite campuses count as hours in residence. Independent Study correspondence courses, petitioned courses and exam credits do not.

#### *Minimum 2.0 Cumulative GPA*

A 2.0 is the minimum GPA to stay in Good Standing at the University of Utah. Some departments may require higher GPAs.

#### *Apply for Graduation*

At least two semesters before graduation you must file an application to graduate

#### *General Education Requirements.*

Students must fulfill the University of Utah's General Education and Bachelor Degree requirements in addition to the METE degree requirements to graduate.

GE website <https://ugs.utah.edu/general-education/requirements/index.php>

### **General Education Requirements:**

#### Lower Division Courses

- Lower Division Writing (WR2) – 1 course
- Quantitative Reasoning (QR) – 1 course
- American Institutions (AI) – 1 course
- QA Math and QB Statistics/Logic (QA, QB) – 2 courses

#### Intellectual Exploration Courses

- Fine Arts (FF,FF) – 2 courses
- Humanities (HF,HF) – 2 courses
- Physical/Life Science (SF) – 1 course
- Physical/Life Science or Applied Science (AS or SF) – 1 course

- Social/Behavioral Science (BF,BF) – 2 courses

#### Bachelor's Degree Courses

- Communication & Writing (CW) – 1 course
- Diversity (DV) – 1 course
- International (IR) – 1 course
- Quantitative Intensive (QI,QI) – 2 courses

#### *Requirements for a Major*

When you enter the University of Utah you are listed as being in pre-major status. This is not the same as being declared into a major. To officially declare your major you must meet with the departmental advisor.

1. Major coursework – see your departmental advisor or run a DARS for a list of requirements for your major
2. Other Departmental or College Requirements – some departments have additional requirements for graduation such as passing comprehensive exams. Check with your departmental advisor.

#### *Second Bachelor's Degree*

Students who have completed a bachelor's degree recognized by the University and now wish to earn a second bachelor's degree must fulfill the following requirements:

1. All requirements for the major
2. Residency Hours Requirement
3. American Institutions\*
4. Lower Division Writing\*
5. Upper Division Communication/Writing\*
6. Diversity\*
7. International Requirement\*
8. Current Requirements for BS

\*Not required if completed in the first bachelor's degree

#### *Associate's Degrees*

Associate of Arts (AA) and Associate of Science (AS) degrees automatically clear some General Education Requirements depending on which school awarded them.

#### **Schools in the Utah System of Higher Education (USHE) and LDS Business College:**

All General Education requirements are cleared with the possible exception of American Institutions (AI), which is checked separately by the Admissions Office.

#### **Private Schools in Utah and all out of state schools:**

Lower Division Writing and all Intellectual Explorations (IE) requirements are cleared automatically. The Admissions Office checks American Institutions (AI), Quantitative Reasoning (QA and QB).

NOTE: an Associate of Applied Science (AAS) degree will not automatically clear any General Education.

### *Course Numbering System*

Noncredit Courses: 0001-0999

Lower Division Courses (Freshman and Sophomore) 1000-2999

Upper Division Courses (Junior and Senior) 3000-5999

Graduate Courses 6000-7990

NOTE: These courses cannot be taken by undergraduate students without special permission from the department.

### *Minimum Grades for General Education and Bachelor's Degree Requirements*

#### American Institutions

American Institutions	D- or CR
Lower Division Writing	C-
Quantitative Reasoning	
QA	D- or CR
QB	D- or CR
Intellectual Explorations (8 courses)	D- or CR
Bachelor's Degree Grade Requirements	
Upper-division Communication/Writing	C- or CR
Diversity	C- or CR
International Requirement	C- or CR
Bachelor of Arts	C- or CR
Bachelor of Science	
Quantitative Intensive I	D- or CR
Quantitative Intensive II	D- or CR

NOTE: Must get a C- or better in required courses.

## Credit for Advanced Placement (AP) Exams

Advanced Placement (AP) Courses and Exams	Major Committee Recommendations Approved by Utah Board of Higher Education	GE awarded
<b>Arts</b>		
Music Theory	Score 3-4 = MUSC 1100 (3 credits) Score 5 = MUSC 1110 (3 credits)	<none> <none>
<b>English</b>		
English Language and Composition	Score 3-5 = WRTG 1010 (3 credits)	WR1 (score of 4-5 = WR2 through U2022)
English Literature and Composition	Score 3-5 = ENGL 2XXX (3 credits)	(score of 4-5 = WR2 through U2022)
<b>History and Social Sciences</b>		
Comparative Government and Politics	Score 3-5 = POLS 2200 (3 credits)	BF
European History	Score 3-5 = HIST 1110 (3 credits)	HF
Human Geography	Score 3-5 = GEOG 1400 (3 credits)	BF
Macroeconomics	Score 3-5 = ECON 2020 (3 credits)	BF
Microeconomics	Score 3-5 = ECON 2010 (3 credits)	BF
Psychology	Score 3-5 = PSY 1010 (3 credits)	BF
United States Government and Politics	Score 3-5 = POLS 1100 (3 credits)	AI
United States History	Score 3-5 = HIST 1700 (3 credits)	AI
World History: Modern	Score 3-5 = HIST 1510 (3 credits)	HF
<b>Math and Computer Science</b>		
Calculus AB	Score 3 = MATH 1050 + MATH 1060 (6 total credits) Score 4-5 = MATH 1210 (4 credits) + MATH 1XXX (2 credits)	QA QR
Calculus BC	Score 3 = MATH 1210 (4 credits) + MATH 1XXX (2 credits) Score 4-5 = MATH 1210 (4 credits) + MATH 1220 (4 credits)	QR QR
Computer Science A	Score 3-4 = CS 1030 (3 credits) Score 5 = CS 1030 (3 credits) + CS 1410 (3 credits)	<none> <none>
Computer Science Principles	Score 3-5 = CS 1030 (3 credits)	<none>
Statistics	Score 3-5 = MATH 1XXX (3 credits)	QB
<b>Sciences</b>		
Biology	Score 3 = BIOL 1010 (3 credits) Score 4-5 = BIOL 1610 (4 credits)	SF SF
Chemistry	Score 3 = CHEM 1010 (3 credits) - Satisfies chem prerequisite for CHEM 1210 Score 4 = CHEM 1210 (4 credits) Score 5 = CHEM 1210 (4 credits) + CHEM 1220 (4 credits)	SF SF SF
Environmental Science	Score 3-5 = ENVST 2050 (3 credits) - No lab credit	SF
Physics 1: Algebra-Based	Score 3 = PHYS 1010 (3 credits) + PHYS 1XXX (1 credit) Score 4-5 = PHYS 2010 (4 credits) + PHYS 2015 (1 credit)	SF SF
Physics 2: Algebra-Based	Score 3 = PHYS 1010 (3 credits) + PHYS 1XXX (1 credit) Score 4-5 = PHYS 2020 (4 credits) + PHYS 2025 (1 credit)	SF SF
Physics C: Electricity and Magnetism	Score 3 = PHYS 1010 (3 credits) + PHYS 1XXX (1 credit) Score 4-5 = PHYS 2220 (4 credits) + lab (1 credit, determined only via Portfolio assessment)	SF SF
Physics C: Mechanics	Score 3 = PHYS 1010 (3 credits) + PHYS 1XXX (1 credit) Score 4-5 = PHYS 2210 (4 credits) + lab (1 credit, determined only via Portfolio assessment)	SF SF
<b>World Languages and Cultures</b>		



Chinese Language and Culture	Score 3 = CHIN 1010 + CHIN 1020 (8 total credits)	<none>
	Score 4 = CHIN 1010 + CHIN 1020 + CHIN 2010 (12 total credits)	<none>
	Score 5 = CHIN 1010 + CHIN 1020 + CHIN 2010 + CHIN 2020 (16 total credits)	LR
French Language and Culture	Score 3 = FRNCH 1010 + FRNCH 1020 (8 total credits)	<none>
	Score 4 = FRNCH 1010 + FRNCH 1020 + FRNCH 2010 (12 total credits)	<none>
	Score 5 = FRNCH 1010 + FRNCH 1020 + FRNCH 2010 + FRNCH 2020 (16 total credits)	LR
German Language and Culture	Score 3 = GERM 1010 + GERM 1020 (8 total credits)	<none>
	Score 4 = GERM 1010 + GERM 1020 + GERM 2010 (12 total credits)	<none>
	Score 5 = GERM 1010 + GERM 1020 + GERM 2010 + GERM 2020 (16 total credits)	LR
Italian Language and Culture	Score 3 = ITAL 1010 + ITAL 1020 (8 total credits)	<none>
	Score 4 = ITAL 1010 + ITAL 1020 + ITAL 2010 (12 total credits)	<none>
	Score 5 = ITAL 1010 + ITAL 1020 + ITAL 2010 + ITAL 2020 (16 total credits)	LR
Japanese Language and Culture	Score 3 = JAPAN 1010 + JAPAN 1020 (8 total credits)	<none>
	Score 4 = JAPAN 1010 + JAPAN 1020 + JAPAN 2010 (12 total credits)	<none>
	Score 5 = JAPAN 1010 + JAPAN 1020 + JAPAN 2010 + JAPAN 2020 (16 total credits)	LR
Spanish Language and Culture	Score 3 = SPAN 1010 + SPAN 1020 (8 total credits)	<none>
	Score 4 = SPAN 1010 + SPAN 1020 + SPAN 2010 (12 total credits)	<none>
	Score 5 = SPAN 1010 + SPAN 1020 + SPAN 2010 + SPAN 2020 (16 total credits)	LR

\*Exam equivalencies are subject to change without notice

4/26/21