Undergraduate Program Guide
for Metallurgical Engineering

The University of Utah
College of Mines and Earth Sciences
and College of Engineering
Department of Materials Science and Engineering

For additional information, contact our
Undergraduate Student Advisor
Telephone: 801-581-6864
Email: metal-advising@lists.utah.edu
Office: 304 Civil & Materials Engineering Bldg

mailing address:
Department of Materials Science and Engineering
University of Utah
122 S Central Campus Dr Rm 304
Salt Lake City, UT 84112

Telephone: (801) 581-6863
www.mse.utah.edu

The Metallurgical Engineering B.S. program at
the University of Utah is accredited by ABET, Inc.

(August 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, commination, 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), 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 Department People You Should Know

Department Chair and Director of Undergraduate Studies
Prof. Michael Simpson
CME 304
michael.simpson@utah.edu
801.555.5555

Academic Advisor
—
CME 304
@utah.edu
801.581.6864

Administrative Manager/Graduate Academic Advisor
Sara Wilson
CME 304
sara.j.wilson@utah.edu
801.581.4449

Administrative Officer
Angela Nelson
CME 304
angela.nelson@utah.edu
801.585.6919

Clerk
Joshua Hansen
CME 304
mss.eng.utah.edu
801.581.6863

Executive Secretary
Kay Argyle
WBB 412B
kay.argyle@utah.edu
801.581.6386
### Materials Science and Engineering Teaching Faculty

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<tr>
<th>Faculty Member &amp; Area of Specialization</th>
<th>Faculty Member &amp; Area of Specialization</th>
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<tbody>
<tr>
<td><strong>Jeff Bates</strong> Assistant Professor (Lecturer) <a href="mailto:jeff.bates@utah.edu">Jeff Bates</a> <strong>Polymers</strong></td>
<td><strong>Dmitry Bedrov</strong> Associate Professor [<a href="mailto:d.bedrov@utah.edu">d.bedrov@utah.edu</a>] <strong>Computational Polymers</strong></td>
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<td><strong>Darryl Butt</strong> Professor &amp; Dean of the College of Mines and Earth Sciences Office: FASB 205 Phone: 801-581-8767 [<a href="mailto:darryl.butt@utah.edu">darryl.butt@utah.edu</a>]</td>
<td><strong>Ravi Chandran</strong> Professor [<a href="mailto:ravi.chandran@utah.edu">ravi.chandran@utah.edu</a>] <strong>Physical metallurgy</strong></td>
</tr>
<tr>
<td><strong>Richard Cohen</strong> <a href="mailto:richard.cohen@utah.edu">richard.cohen@utah.edu</a></td>
<td><strong>Raymond Cutler</strong> <a href="mailto:r.cutler@utah.edu">r.cutler@utah.edu</a></td>
</tr>
<tr>
<td><strong>Zak Fang</strong> Professor <a href="mailto:zak.fang@utah.edu">zak.fang@utah.edu</a> <strong>Metals for energy storage</strong> <strong>Powder metallurgy</strong></td>
<td><strong>Michael Free</strong> Professor <a href="mailto:michael.free@utah.edu">michael.free@utah.edu</a> <strong>Hydrometallurgy</strong> <strong>Electrometallurgy</strong></td>
</tr>
<tr>
<td><strong>Sivaraman Guruswamy</strong> Professor <a href="mailto:s.guruswamy@utah.edu">s.guruswamy@utah.edu</a> <strong>Physical metallurgy</strong> <strong>Magnetic materials</strong></td>
<td><strong>Huiwen Ji</strong> Assistant Professor Office: CME 212 Phone: 801-585-7171 <a href="mailto:huiwen.ji@utah.edu">huiwen.ji@utah.edu</a></td>
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<tr>
<td><strong>Feng Liu</strong> Professor <a href="mailto:fliu@eng.utah.edu">fliu@eng.utah.edu</a> <strong>Computational Electronic Materials</strong></td>
<td><strong>Jan Miller</strong> Distinguished Professor &amp; Ivor Thomas Professor of Metallurgical Engineering <a href="mailto:jan.miller@utah.edu">jan.miller@utah.edu</a> <strong>Mineral Processing</strong></td>
</tr>
</tbody>
</table>
Swomitra "Bobby" Mohanty
Assistant Professor
swomitra.mohanty@utah.edu
Nano-technology
Sensors

Raj Rajamani
Professor
raj.rajamani@utah.edu
Particle Processing

Michael Scarpulla
Associate Professor
scarpulla@eng.utah.edu
Electronic Materials

Michael Simpson
Professor and Chair
michael.simpson@utah.edu
Nuclear Materials
Molten Salts

York Smith
Assistant Professor
york.smith@utah.edu
Chemical Metallurgy
Metal Recycling

Hong Yong Sohn
Distinguished Professor
h.y.sohn@utah.edu
Chemical metallurgy

Taylor Sparks
Associate Professor and
Associate Chair
sparks@eng.utah.edu
Ceramics

Gerald Stringfellow
Distinguished Professor
Office: MEB 3110
Phone: 801-581-8387
stringfellow@coe.utah.edu

Ashutosh Tiwari
Professor
tiwari@eng.utah.edu
Nanotechnology/
Electronic Materials

Anil Virkar
Distinguished Professor
Office: CME 316-315
Phone: 801-581-5396
anil.virkar@m.cc.utah.edu

Ling Zang
Professor
lzang@eng.utah.edu
Nanomaterials
## Metallurgical Engineering B.S. Major 2020-2021

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<th>First Year</th>
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<td>MET E 1630</td>
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<td>MATH 2210</td>
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<td>MET E 5710</td>
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<td>MATH 2250</td>
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<td>(4 credits)</td>
<td>MET E 5780</td>
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16 credits | 14.5 credits | 17 credits | 16 credits | 15 credits | 15 credits | 16 credits | 16 credits

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**Department of Materials Science & Engineering**

**College of Mines & Earth Sciences**

**University of Utah**

www.mse.utah.edu

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**Total Required credits: 125.5 or more**

- **Emphasis:** 12 or more credits
- **Technical Elective:** 9 credits
- **G- grade or better**

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**Key**

- **Prerequisites recommended**
- **Recommended Co-requisites**
Undergraduate Metallurgical Engineering Course Descriptions
(see also https://catalog.utah.edu/#/programs/EJCUtxb0Z?bc=true&bcCurrent=Metallurgical%20Engineering&bcItemType=programs)

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 calculations 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 a 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, commination 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 nanoscale and principles and fabrication of nanoscale 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 cermets.

MET E 5360 - 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 5600 - 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 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.

<table>
<thead>
<tr>
<th>Required for BD&amp;S Emphasis</th>
<th>Two of the Following Courses</th>
</tr>
</thead>
<tbody>
<tr>
<td>MET E 5520 Biomedical Devices and Sensors</td>
<td>MET E 5320 Materials and Environment</td>
</tr>
<tr>
<td>MET E 5600 Corrosion</td>
<td>MET E 5770 Electrometallurgy</td>
</tr>
<tr>
<td>MET E 5690 Process Engineering Statistics</td>
<td>MSE 5040 Intro to Modern Biomaterials</td>
</tr>
<tr>
<td></td>
<td>BIOEN 1020 Fund. of Bioengineering</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Required for Chemical Processing Emphasis</th>
<th>Three of the Following Courses</th>
</tr>
</thead>
<tbody>
<tr>
<td>MET E 5600 Corrosion OR MET E 5770 Electrometallurgy</td>
<td>CHEM 2310 Organic Chemistry</td>
</tr>
<tr>
<td></td>
<td>CHEM 3100 Inorganic Chemistry</td>
</tr>
<tr>
<td></td>
<td>CH EN 3353 Fluid Mechanics</td>
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<tr>
<td></td>
<td>MET E 5210 Nuclear Materials</td>
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<tr>
<td></td>
<td>MET E 5330 Renewable Energy Conversion &amp; Storage</td>
</tr>
<tr>
<td></td>
<td>MET E 5520 Biomedical Devices and Sensors</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Required for EC&amp;S Emphasis</th>
<th>Three of the Following Courses</th>
</tr>
</thead>
<tbody>
<tr>
<td>MET E 5330 Renewable Energy Conversion &amp; Storage</td>
<td>MET E 5320 Materials and Environment</td>
</tr>
<tr>
<td></td>
<td>MET E 5600 Corrosion</td>
</tr>
<tr>
<td>MSE 5074 Photovolta. Materials &amp; Solar Cells OR MET E 5770 Electrometallurgy</td>
<td>MET E 5210 Nuclear Materials</td>
</tr>
<tr>
<td></td>
<td>MSE 3210 Electronic Prop. Of Solids</td>
</tr>
</tbody>
</table>
**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 de-watering. 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.

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

**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.

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

**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.

<table>
<thead>
<tr>
<th>Required for Emphasis</th>
<th>Three of the Following Courses</th>
</tr>
</thead>
<tbody>
<tr>
<td>MET E 5270 Powder Metallurgy</td>
<td>MET E 5320 Materials and Environment</td>
</tr>
<tr>
<td>MET E 5300 Alloy and Material Design</td>
<td>MET E 5330 Renewable Energy Conversion &amp; Storage</td>
</tr>
<tr>
<td></td>
<td>MET E 5520 Biomedical Devices &amp; Sensors</td>
</tr>
<tr>
<td></td>
<td>MET E 5600 Corrosion</td>
</tr>
<tr>
<td></td>
<td>MET E 5690 Process Engineering Statistics</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Math ACT Score(s)</th>
<th>Math SAT Score(s)</th>
<th>Accuplacer Scores*</th>
<th>Course Placement</th>
</tr>
</thead>
<tbody>
<tr>
<td>17 or lower</td>
<td>420 or lower</td>
<td>AR &lt; 120 or EA &lt; 54</td>
<td>Math 990 Elementary Algebra</td>
</tr>
<tr>
<td>18-22</td>
<td>430-530</td>
<td>54 &lt;= EA or CLM &lt; 50</td>
<td>Math 1010 Intermediate Algebra**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CLM &gt;= 60</td>
<td>Math 1050 College Algebra Math 1060 Trigonometry</td>
</tr>
<tr>
<td>24-27</td>
<td>58-620</td>
<td>CLM &gt;= 65</td>
<td>Math 1080 Precalculus</td>
</tr>
<tr>
<td>28 or higher</td>
<td>630 or higher</td>
<td>CLM &gt;= 80</td>
<td>Math 1100 Quantitative Analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>90 &lt;= CLM &lt;= 94***</td>
<td>Math 1210 Calculus I</td>
</tr>
<tr>
<td></td>
<td></td>
<td>95 &lt;= CLM &lt;= 120</td>
<td>Math 1310 Engineering Calculus I</td>
</tr>
</tbody>
</table>

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

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) 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:

   - Literature Survey of General Project Topic(s)
   - Experimental Information
   - Data Presentation and Analysis
   - 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). 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

OVERVIEW OF 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 a letter grade and a higher grade may be required.

Academic Standards

1. Total Semester Credit Hours
   A minimum of 122 semester credit hours is required for a bachelor’s degree.

2. Upper Division Credit Hours
   At least 40 of the required 122 semester hours must be at the 3000 level or above. (BUS degrees require 55.) Credits from 2-year schools will not count toward upper division hours.

3. Residency Hours
   a) A minimum of 30 semester hours must be completed at the University of Utah.
   b) 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.

4. 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.

5. Apply for Graduation
   At least two semesters before graduation you must file an application to graduate.
   Click on the Graduation Tile in CUS.

General Education Requirements

1. American Institutions (AI) (D- or CR)
   One course from the approved list

2. Lower Division Writing (WR2)
   (C- must be taken for a letter grade)
   Most students will take the Writing 1010/1020 series to complete this requirement. Students for whom English is their second language take the ESL 1040/1050/1060 series. Honors program students can take HONORS 2211.

3. Quantitative Reasoning (QA and QB) (D- or CR)
   (QA) Math 1030 or higher except Math 1040, 1060, or 1070
   (NOTE: A grade of C or higher is required for any necessary prerequisite(s) to the QA requirement.)
   (QB) One course in statistics or logic from the approved list.
   (NOTE: A course in calculus or higher math satisfies both QA and QB.)

   4. Intellectual Exploration (IE) (D- or CR)
      Take two courses from approved lists in each of the following four areas:
      Fine Arts (FF)
      Humanities (HF)
      Physical, Life and Applied Science (SF) (AS)
      Social and Behavioral Science (BF)
      (You are not required to take IE courses in the area of your major. See p. 4 to identify the area of your major.)

Bachelor’s Degree Requirements

1. Upper Division Communication/Writing (CW) (C- or CR)
   Choose one course from the approved list. Some departments require a specific course. Meet with your departmental advisor before choosing a course.

2. Diversity (DV) (C- or CR)
   Choose one course from the approved list.

3. Upper Division International Requirement (IR) (C- or CR)
   Choose one course from the approved list or participate in an approved study abroad program (see page 19-IR requirements). Required of all students beginning their enrollment at the U Fall 2007 or after. (Not required of students who took a course at the U prior to Fall 2007 as long as they graduated by summer 2013. Beginning Fall 2013 all students will be required to complete this requirement regardless of their entrance date.)

4. Bachelor of Science and Bachelor of Social Work Upper Division Quantitative Intensive Requirement (QI) (C- or CR)
   Choose two upper division courses from the approved list. Some departments require specific courses. Meet with your departmental advisor before choosing courses.

5. Bachelor of Arts Language Requirement (C- or CR)
   Fourth semester proficiency in a foreign language or American Sign Language

6. Bachelor of Fine Arts, Bachelor of Music
   (Exempt from BA language, BS Quantitative Intensive, and QB Statistics Requirements)

Requirements for a Major

When you enter the University of Utah you are listed as being in premajor status. This is not the same as being declared into a major. To officially declare your major you must meet with the departmental advisor. At mae.utah.edu, click on People/Students/Academic 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.
OVERVIEW OF REQUIREMENTS

Second Bachelor’s Degrees
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, BA, BFA, BMus, BUS*
*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
6000-7999
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

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Grade Acceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Institutions</td>
<td>D- or CR</td>
</tr>
<tr>
<td>Lower Division Writing</td>
<td>C-</td>
</tr>
<tr>
<td>Quantitative Reasoning</td>
<td>D- or CR</td>
</tr>
<tr>
<td>QA</td>
<td>D- or CR</td>
</tr>
<tr>
<td>QB</td>
<td>D- or CR</td>
</tr>
<tr>
<td>Intellectual Explorations (8 courses)</td>
<td>D- or CR</td>
</tr>
<tr>
<td>Bachelor’s Degree Grade Requirements</td>
<td>C- or CR</td>
</tr>
<tr>
<td>Upper-division Communication/Writing</td>
<td>C- or CR</td>
</tr>
<tr>
<td>Diversity</td>
<td>C- or CR</td>
</tr>
<tr>
<td>International Requirement</td>
<td>C- or CR</td>
</tr>
<tr>
<td>Bachelor of Arts</td>
<td>C- or CR</td>
</tr>
<tr>
<td>Bachelor of Science</td>
<td>D- or CR</td>
</tr>
<tr>
<td>Quantitative Intensive I</td>
<td>D- or CR</td>
</tr>
<tr>
<td>Quantitative Intensive II</td>
<td>D- or CR</td>
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</tbody>
</table>

Note: Must get a C- or better in required courses.
# AP Credit and General Education Guide

**University of Utah**

**Credit for Advanced Placement (AP) Exams**

<table>
<thead>
<tr>
<th>Advanced Placement (AP) Courses and Exams</th>
<th>Major Committee Recommendations Approved by Utah Board of Higher Education</th>
<th>GE awarded</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Arts</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Music Theory</td>
<td>Score 3-4 = MUSC 1100 (3 credits)</td>
<td>&lt;none&gt;</td>
</tr>
<tr>
<td></td>
<td>Score 3 = MUSC 1110 (3 credits)</td>
<td>&lt;none&gt;</td>
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<tr>
<td><strong>English</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English Language and Composition</td>
<td>Score 3-5 = WRTG 1010 (8 credits)</td>
<td>WR1 (score of 4-5 = WR2 through UO22)</td>
</tr>
<tr>
<td>English Literature and Composition</td>
<td>Score 3-5 = ENGL 2XXX (3 credits)</td>
<td>(score of 4-5 = WR2 through UO22)</td>
</tr>
<tr>
<td><strong>History and Social Sciences</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comparative Government and Politics</td>
<td>Score 3.5 = POLS 2200 (3 credits)</td>
<td>BF</td>
</tr>
<tr>
<td>European History</td>
<td>Score 3.5 = HIST 1110 (3 credits)</td>
<td>HF</td>
</tr>
<tr>
<td>Human Geography</td>
<td>Score 3.5 = GEOG 1400 (3 credits)</td>
<td>BF</td>
</tr>
<tr>
<td>Macroeconomics</td>
<td>Score 3.5 = ECON 2010 (3 credits)</td>
<td>BF</td>
</tr>
<tr>
<td>Microeconomics</td>
<td>Score 3.5 = ECON 2010 (3 credits)</td>
<td>BF</td>
</tr>
<tr>
<td>Psychology</td>
<td>Score 3.5 = PSY 1010 (3 credits)</td>
<td>BF</td>
</tr>
<tr>
<td>United States Government and Politics</td>
<td>Score 3.5 = POLS 1100 (3 credits)</td>
<td>AI</td>
</tr>
<tr>
<td>United States History</td>
<td>Score 3.5 = HIST 1700 (3 credits)</td>
<td>AI</td>
</tr>
<tr>
<td>World History, Modern</td>
<td>Score 3.5 = HIST 1510 (3 credits)</td>
<td>HF</td>
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<tr>
<td><strong>Math and Computer Science</strong></td>
<td></td>
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<tr>
<td>Calculus AB</td>
<td>Score 3 = MATH 1030 + MATH 1060 (6 total credits)</td>
<td>QA</td>
</tr>
<tr>
<td></td>
<td>Score 4-5 = MATH 1210 (4 credits) + MATH 1XXX (2 credits)</td>
<td>QR</td>
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<tr>
<td>Calculus BC</td>
<td>Score 3 = MATH 1210 (4 credits) + MATH 1XXX (2 credits)</td>
<td>QR</td>
</tr>
<tr>
<td></td>
<td>Score 4-5 = MATH 1210 (4 credits) + MATH 1220 (4 credits)</td>
<td>QR</td>
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<tr>
<td>Computer Science A</td>
<td>Score 3-4 = CS 1030 (3 credits)</td>
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<td></td>
<td>Score 5 = CS 1030 (3 credits) + CS 1410 (3 credits)</td>
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<tr>
<td>Computer Science Principles</td>
<td>Score 3.5 = CS 1050 (3 credits)</td>
<td>&lt;none&gt;</td>
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<tr>
<td>Statistics</td>
<td>Score 3.5 = MATH 1XXX (3 credits)</td>
<td>QB</td>
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<tr>
<td><strong>Sciences</strong></td>
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<tr>
<td>Biology</td>
<td>Score 3 = BIOL 1010 (3 credits)</td>
<td>SF</td>
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<tr>
<td></td>
<td>Score 4-5 = BIOL 1610 (4 credits)</td>
<td>SF</td>
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<tr>
<td>Chemistry</td>
<td>Score 3 = CHEM 1010 (3 credits) - Satisfies chem prerequisite for CHEM 1210</td>
<td>SF</td>
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<tr>
<td></td>
<td>Score 4 = CHEM 1210 (4 credits)</td>
<td>SF</td>
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<tr>
<td></td>
<td>Score 5 = CHEM 1210 (4 credits) + CHEM 1220 (4 credits)</td>
<td>SF</td>
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<tr>
<td>Environmental Science</td>
<td>Score 3.5 = ENVS 2050 (3 credits) - No lab credit</td>
<td>SF</td>
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<tr>
<td>Physics 1: Algebra-Based</td>
<td>Score 3 = PHYS 1010 (3 credits) + PHYS 1XXX (1 credit)</td>
<td>SF</td>
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<td></td>
<td>Score 4-5 = PHYS 2010 (4 credits) + PHYS 2015 (1 credit)</td>
<td>SF</td>
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<tr>
<td>Physics 2: Algebra-Based</td>
<td>Score 3 = PHYS 1010 (3 credits) + PHYS 1XXX (1 credit)</td>
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<td></td>
<td>Score 4-5 = PHYS 2020 (4 credits) + PHYS 2025 (1 credit)</td>
<td>SF</td>
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<tr>
<td>Physics C: Electricity and Magnetism</td>
<td>Score 3 = PHYS 1010 (3 credits) + PHYS 1XXX (1 credit)</td>
<td>SF</td>
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<tr>
<td></td>
<td>Score 4-5 = PHYS 2210 (4 credits) + lab (1 credit, determined only via Portfolio assessment)</td>
<td>SF</td>
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<tr>
<td>Physics C: Mechanics</td>
<td>Score 3 = PHYS 1010 (3 credits) + PHYS 1XXX (1 credit)</td>
<td>SF</td>
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<tr>
<td></td>
<td>Score 4-5 = PHYS 2210 (4 credits) + lab (1 credit, determined only via Portfolio assessment)</td>
<td>SF</td>
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<tr>
<td><strong>World Languages and Cultures</strong></td>
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<tr>
<td>Chinese Language and Culture</td>
<td>Score 3 = CHIN 1010 + CHIN 1020 (8 total credits)</td>
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<td></td>
<td>Score 4 = CHIN 1010 + CHIN 1020 + CHIN 2100 (12 total credits)</td>
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<tr>
<td></td>
<td>Score 5 = CHIN 1010 + CHIN 1020 + CHIN 2100 + CHIN 2200 (16 total credits)</td>
<td>LR</td>
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<tr>
<td>French Language and Culture</td>
<td>Score 3 = FRNC 1010 + FRNC 1020 (8 total credits)</td>
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<td>Score 4 = FRNC 1010 + FRNC 1020 + FRNC 2100 (12 total credits)</td>
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<td>Score 5 = FRNC 1010 + FRNC 1020 + FRNC 2100 + FRNC 2200 (16 total credits)</td>
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<td>German Language and Culture</td>
<td>Score 3 = GERM 1010 + GERM 1020 (8 total credits)</td>
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<td></td>
<td>Score 4 = GERM 1010 + GERM 1020 + GERM 2100 (12 total credits)</td>
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<tr>
<td></td>
<td>Score 5 = GERM 1010 + GERM 1020 + GERM 2100 + GERM 2200 (16 total credits)</td>
<td>LR</td>
</tr>
<tr>
<td>Italian Language and Culture</td>
<td>Score 3 = ITAL 1010 + ITAL 1020 (8 total credits)</td>
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<td></td>
<td>Score 4 = ITAL 1010 + ITAL 1020 + ITAL 2100 (12 total credits)</td>
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<tr>
<td></td>
<td>Score 5 = ITAL 1010 + ITAL 1020 + ITAL 2100 + ITAL 2200 (16 total credits)</td>
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<tr>
<td>Japanese Language and Culture</td>
<td>Score 3 = JAPN 1010 + JAPN 1020 (8 total credits)</td>
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<td>Score 4 = JAPN 1010 + JAPN 1020 + JAPN 2100 (12 total credits)</td>
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<tr>
<td></td>
<td>Score 5 = JAPN 1010 + JAPN 1020 + JAPN 2100 + JAPN 2200 (16 total credits)</td>
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</tr>
<tr>
<td>Spanish Language and Culture</td>
<td>Score 3 = SPAN 1010 + SPAN 1020 (8 total credits)</td>
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<tr>
<td></td>
<td>Score 4 = SPAN 1010 + SPAN 1020 + SPAN 2100 (12 total credits)</td>
<td>&lt;none&gt;</td>
</tr>
<tr>
<td></td>
<td>Score 5 = SPAN 1010 + SPAN 1020 + SPAN 2100 + SPAN 2200 (16 total credits)</td>
<td>LR</td>
</tr>
</tbody>
</table>

*Exam equivalencies are subject to change without notice*