Some quick facts...

- **Two full degree tracks** available in *Materials Science and Engineering* or in *Welding Engineering*
- **Student body**: 400+ undergraduates, 235+ graduate students (175 on-campus; 60 in on-line MS).
- **Current faculty**: 30+ new faculty being hired. Our faculty generate over 300 papers per year.
- **Research equipment** valued at $50 million housed in nearly 100,000 sq. ft. of office/lab space.
- **Research budget**: $17 million (some of the highest research funding per faculty at Ohio State).

MSE is home to the **Center for Electron Microscopy and Analysis (CEMAS)** - Widely regarded as the best electron microscopy center in the world, CEMAS is a $15M facility dedicated to the characterization of materials. Equipment includes two aberration-corrected Scanning Transmission Electron Microscopes capable of imaging and analyzing materials on the atomic scale, as well as, Transmission Electron Microscopes, Scanning Electron Microscopes, and X-Ray Diffractometers, all available for student use. [cemas.osu.edu](http://cemas.osu.edu)

- **Many world-class research centers** are part of the MSE-WE department, here are a few:
  - **Manufacturing & Materials Joining Innovation Center (MA2JIC)** seeks to close the gap between new material development and the joining of these materials, with special emphasis on the application of welding technologies to energy industries. [ma2jic.osu.edu](http://ma2jic.osu.edu)
  - **Fontana Corrosion Center (FCC)** The FCC focuses on the study of aqueous corrosion in an effort to protect materials from the harmful effects of degradation. [fcc.osu.edu](http://fcc.osu.edu)
  - **Center for Accelerated Maturation of Materials (CAMM)** CAMM works to speed the often lengthy development time involved in bringing a theoretical material through the development stage to final fabrication by means of computational simulation. [camm.osu.edu](http://camm.osu.edu)
  - **Center for Emergent Materials (CEM)** The CEM is an NSF MRSEC. The Center will develop new electronic materials with an emphasis on magnetoelectronics. [cem.osu.edu](http://cem.osu.edu)
  - **Nanoscale Science and Engineering Center (NSEC)** NSEC seeks to make affordable manufacturing methods to form, reinforce, bond, and assemble polymer structures at the nanoscale for biomedical and other applications. [www.nsec.ohio-state.edu](http://www.nsec.ohio-state.edu)
  - **Center for Superconducting and Magnetic Materials (CSMM)** The research focus of CSMM includes the processing and properties of superconducting wires for high magnetic field applications. [csmm.osu.edu](http://csmm.osu.edu)

**Graduate Studies**

- **Distance degree in Welding Engineering** The Welding Engineering program offers both a certificate in WE and a Master's non-thesis degree which can be completed 100% on-line.
- **Starting salaries** for our Master's and Ph.D. recipients can be in excess of $80,000. The study of MSE and WE is not simply intellectually rewarding; a graduate degree in our program will be a great boost for your career as well!
- **MSE and WE are multi-disciplinary fields.** Students with backgrounds other than MSE or WE are uniquely qualified to bring their knowledge to the study of materials science.

[mse.osu.edu](http://mse.osu.edu)
| **Sheikh Akbar, Professor** | Ceramic materials  
Sensors  
Nanomaterials |
| --- | --- |
| Materials Science and Engineering  
Advanced Materials Building  
614-292-6725  
akbar.1@osu.edu  
Ph.D., Purdue University 1985 |
| Synthesis-microstructure-property relations of ceramic bulk, thin-film and nanostructures for electrochemical devices such as sensors and biomedical applications |

| **Boian Alexandrov, Research Professor** | Welding Engineering  
Metallurgy |
| --- | --- |
| Welding Engineering  
128 EJTC  
614-292-735  
alexandrov.1@osu.edu  
Ph.D., Technical Un of Sofia, Bulgaria |
| Physical/welding metallurgy of structural alloys; Weldability testing; Weld failure analysis; Weld phenomena modeling; Welding processes |

| **Peter Anderson, Professor** | Metallurgy  
Characterization  
Computational materials |
| --- | --- |
| Materials Science and Engineering  
614-292-0176  
anderson.1@osu.edu  
Ph.D., Harvard University 1986 |
| Mechanical properties and underlying physics of deformation, with applications to metals, shape memory alloys, nanostructured materials, and tissue scaffolds; Computational methods for mechanical behavior |

| **Avi Benatar, Associate Professor** | Welding engineering  
Polymers joining  
Modeling |
| --- | --- |
| Welding Engineering  
124 EJTC  
614-292-1390  
benatar.1@osu.edu  
Ph.D., MIT 1987 |
| Engineering analysis; Joining plastics and composites; Simulation of welding processes; Welding design |

| **Desmond Bourgeois, Assistant Professor** | Welding engineering  
Processes  
Characterization |
| --- | --- |
| Welding Engineering  
EJTC  
bourgeois.16@osu.edu  
Ph.D., Ohio State 2015 |
| Nondestructive evaluation of welded materials; in-process monitoring of additive manufacturing and welding processes; development of advanced nondestructive techniques; ultrasonic microstructural characterization |

| **Enam Chowdhury, Assistant Professor** | Manufacturing processes  
Nanomaterials |
| --- | --- |
| Materials Science and Engineering  
614-292-4286  
chowdhury.24@osu.edu  
Ph.D., University of Delaware 2004 |
| Laser materials processing; Ultrafast laser; Laser damage and ablation; Laser plasma particle acceleration; High and ultra-high intensity laser technology; Warm dense matter; Laser surface engineering |

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**125 MSE**  
**99 WE**  
Graduate students enrollment  
Autumn 2020

**30 MSE**  
**23 WE**  
Master of Science Degrees Conferred  
2020

**19 MSE**  
**6 WE**  
Doctor of Philosophy Degrees Conferred  
2020
## Research

### Focus Areas with Dedicated Faculty

<table>
<thead>
<tr>
<th>Faculty Member</th>
<th>Department</th>
<th>Research Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glenn Daehn, Professor</td>
<td>Materials Science and Engineering</td>
<td>Manufacturing and processing, focused on impulse (high speed and pressure) methods</td>
</tr>
<tr>
<td>David Dean, Associate Professor</td>
<td>Materials Science and Engineering</td>
<td>Biomaterials, Biomedical modeling, Manufacturing processes</td>
</tr>
<tr>
<td>Vicky Doan-Nguyen, Assistant Professor</td>
<td>Materials Science and Engineering</td>
<td>Nanomaterials, Energy storage, Materials characterization</td>
</tr>
<tr>
<td>Suliman Dregia, Associate Professor</td>
<td>Materials Science and Engineering</td>
<td>Electronic materials, Thin films</td>
</tr>
<tr>
<td>Dave Farson, Associate Professor</td>
<td>Welding Engineering</td>
<td>Welding Engineering, Processes, Modeling</td>
</tr>
<tr>
<td>Carolin Fink, Assistant Professor</td>
<td>Welding Engineering</td>
<td>Welding Engineering, Characterization, Modeling</td>
</tr>
<tr>
<td>Gerald Frankel, Professor</td>
<td>Materials Science and Engineering</td>
<td>Corrosion, Metallurgy</td>
</tr>
</tbody>
</table>

### Department Research Facilities

- Center for Accelerated Maturation of Materials (Camm)
- Center for Electron Microscopy and Analysis (CEMAS)
- Center for Performance and Design of Nuclear Waste Forms and Containers (WastePD)
- Center for Superconducting and Magnetic Materials (CSMM)
- Fontana Corrosion Center (FCC)
- Manufacturing and Materials Joining Innovation Center (Ma2JIC)
- Impulse Manufacturing Lab (IML)

### Multidisciplinary Centers

- Center for Automotive Research
- Center for Design and Manufacturing Excellence
- Center for Emergent Materials
- Center for Regenerative Medicine and Cell-Based Therapies
- Institute for Materials Research
- Simulation Innovation and Modeling Center

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mse.osu.edu Department of Materials Science and Engineering
Hamish Fraser, Ohio Regents Eminent Scholar, Professor, Director of CAMM
Materials Science and Engineering
107 CEMAS  614-643-3110  fraser.3@osu.edu
Ph.D., University of Birmingham, U.K. 1972
Analytical electron microscopy; Material processing; High-temperature materials; Interfaces; Advanced materials

Maryam Ghazisaeidi, Associate Professor
Materials Science and Engineering
614-292-8474  ghazisaeidi.1@osu.edu
Ph.D., University of Illinois Urbana-Champaign 2011
Computational materials science; Materials structure; First-principles calculations; Atomic-scale investigation of deformation mechanisms

Perena Gouma, Professor, Edward Orton, Jr., Chair of Ceramic Engineering
Materials Science and Engineering
614-292-4931  gouma.2@osu.edu
Ph.D., University of Birmingham, U.K. 1972
Nanomaterials; Polymorphic metal oxides; Biochemical sensors; Photochemical reaction catalysts; Scalable nanomanufacturing; Smart health

Tyler Grassman, Assistant Professor
Materials Science and Engineering - Electrical and Computer Engineering
Advanced Materials Building  614-688-1704  grassman.5@osu.edu
Ph.D., University of California, San Diego 2007
Electronic and photonic materials; Nanostructured materials; Surface and interface science; Photovoltaics; Optoelectronics

Dennis Harwig, Research Associate Professor
Welding Engineering
110 EJTC  614-440-5124  harwig.4@osu.edu
Ph.D., Cranfield University 2003
Metal additive manufacturing; Directed energy deposition; Computer aided robotics; Arc welding processes & controls; Metal transfer waveform design; Shipbuilding; Standards; Die casting; Die materials

Jinwoo Hwang, Assistant Professor
Materials Science and Engineering
111 CEMAS  614-643-3459  hwang.458@osu.edu
Ph.D., University of Wisconsin 2011
Electron microscopy; Structure-property relationship in complex oxides interfaces; III-V semiconductors; Organic solar cells; Structure and deformation of disordered materials; STEM technique development; Materials modeling

Joerg Jinschek, Associate Professor
Materials Science and Engineering
113 CEMAS  614-643-3110  jinschek.1@osu.edu
Ph.D., Friedrich-Schiller University Jena, Germany, 2001
Advanced materials characterization and modeling, focusing on (in-situ) electron microscopy; Structure-property relationship in functional nanomaterials, such as catalysts, alloys, soft materials, biomimetics

John Lannutti, Professor
Materials Science and Engineering
Advanced Materials Building  614-292-3926  lannutti.1@osu.edu
Ph.D., University of Washington 1990
Biomaterials for cancer research and disease detection; Smart tissue scaffolds; Up/down-conversion of electromagnetic energy; Self-reporting electrospun matrices; Connections between nanoscale fiber structure and macroscopic properties

Aeriel Leonard, Assistant Professor
Materials Science and Engineering
leonard.649@osu.edu
Ph.D., University of Michigan 2018
In-situ synchrotron and electron microscopy techniques for mechanical behavior and microstructural evolution; Lightweight materials (Al, Mg); Alloy adaption for additive manufacturing; Integrated computational materials engineering

$17.2 million
Research expenditures in the Department of Materials Science and Engineering
2020 Annual Statistical Report  |  College of Engineering Research Expenditures by Department
mse.osu.edu  |  Department of Materials Science and Engineering
<table>
<thead>
<tr>
<th>Name</th>
<th>Department</th>
<th>Email Address</th>
<th>Ph.D. Institution and Year</th>
<th>Interests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jinghua Li, Assistant Professor</td>
<td>Materials Science and Engineering</td>
<td><a href="mailto:li.11017@osu.edu">li.11017@osu.edu</a></td>
<td>Duke University 2016</td>
<td>Biomaterials; Polymers; Bioelectronics: thin-film materials and electronic devices that enable highly-sensitive, real-time and long-term monitoring of biophysical and biochemical information in relation to advanced healthcare</td>
</tr>
<tr>
<td>Xun Liu, Assistant Professor</td>
<td>Welding Engineering</td>
<td><a href="mailto:liu.7054@osu.edu">liu.7054@osu.edu</a></td>
<td>University of Michigan 2016</td>
<td>Welding Engineering; Manufacturing processes; Modeling; Solid state joining; Advanced manufacturing process; Materials characterization and modeling; 4D Printing</td>
</tr>
<tr>
<td>Jennifer Locke, Assistant Professor</td>
<td>Materials Science and Engineering</td>
<td><a href="mailto:locke.121@osu.edu">locke.121@osu.edu</a></td>
<td>University of Virginia 2010</td>
<td>Corrosion; Metallurgy; Corrosion and environmental fracture/cracking of metals and alloys; Thermo-mechanical processing effects on corrosion and environmental cracking</td>
</tr>
<tr>
<td>Alan Luo, Professor</td>
<td>Materials Science and Engineering</td>
<td><a href="mailto:luo.446@osu.edu">luo.446@osu.edu</a></td>
<td>University of Windsor 1993</td>
<td>Metallurgy; Solidification; Advanced metallic materials for transportation applications; Manufacturing processes for light metals (Al, Mg, Ti); Solidification; Integrated computational materials engineering</td>
</tr>
<tr>
<td>David McComb, Professor</td>
<td>Materials Science and Engineering</td>
<td><a href="mailto:mccomb.29@osu.edu">mccomb.29@osu.edu</a></td>
<td>Cambridge University 1990</td>
<td>Biomaterials; Electronic microscopy; Investigation of chemistry, structure and bonding in electronic, functional, nano- and biomaterials using advanced electron microscopy techniques</td>
</tr>
<tr>
<td>Michael Mills, Professor</td>
<td>Materials Science and Engineering</td>
<td><a href="mailto:mills.108@osu.edu">mills.108@osu.edu</a></td>
<td>Stanford University 1985</td>
<td>Metallurgy; Characterization; Intermetallic compounds; Metallic alloys; Mechanical properties; Microstructural characterization; High resolution Transmission Electron Microscopy</td>
</tr>
<tr>
<td>Patricia Morris, Associate Professor</td>
<td>Materials Science and Engineering</td>
<td><a href="mailto:morris.692@osu.edu">morris.692@osu.edu</a></td>
<td>MIT 1986</td>
<td>Sensors; Optimization of materials properties by processing to obtain unique defect, surface, nano- and micro-structures; Development of new materials and devices</td>
</tr>
<tr>
<td>Roberto Myers, Professor</td>
<td>Materials Science and Engineering</td>
<td><a href="mailto:myers.1079@osu.edu">myers.1079@osu.edu</a></td>
<td>University of California, Santa Barbara 2006</td>
<td>Electronic materials; Nanomaterials; Characterization; Electronic materials; Optimization of materials properties by processing to obtain unique defect, surface, nano- and micro-structures; Development of new materials and devices</td>
</tr>
<tr>
<td>Stephen Niezgoda, Assistant Professor</td>
<td>Materials Science and Engineering</td>
<td><a href="mailto:niezgoda.6@osu.edu">niezgoda.6@osu.edu</a></td>
<td>Drexel University 2009</td>
<td>Metallurgy; Modeling; Crystal plasticity; Experimental and simulation co-design techniques; Computational material design tools; Materials data sciences; Structural materials; Materials processing; Materials mechanics</td>
</tr>
<tr>
<td>Boyd Panton, Lincoln Electric Company Endowed Assistant Professor</td>
<td>Welding Engineering</td>
<td><a href="mailto:panton.7@osu.edu">panton.7@osu.edu</a></td>
<td>University of Waterloo, Canada 2016</td>
<td>Welding Engineering; Metallurgy; Laser welding processes; Micro-welding; Welding process control; Dissimilar joining; Shape memory alloys</td>
</tr>
</tbody>
</table>
Graduate Research Associateship (GRA)

Purpose
A graduate student's principal objective is to earn a graduate degree. Appointment as a Graduate Research Associate (GRA) provides an apprenticeship experience along with financial support. This apprenticeship complements formal instruction and gives the student practical, personal experience that can be gained only by performing research activities. These positions are, in essence, half-time employment positions and are crucial to research endeavors at The Ohio State University.

Benefits
GRA positions provide for academic and living costs associated with pursuit of a Master's or Ph.D. degree. The total value of tuition and benefits provided over the course of five years can exceed $400,000. A GRA position provides the student with:

• Payment of tuition costs during each term of enrollment.
• Payment of a monthly stipend which, in light of the reasonable cost of living in Columbus, will provide for one's needs while allowing the student to focus on academics and research.
• Payment of 85% of the student's health insurance premiums.
• Payment of computer lab fees. This permits the student access to some of the best computing facilities and equipment on campus.
• Payment of thesis-related research expenses.
• Travel costs for conference expenses may also be provided.
• Access to state-of-the-art research facilities and faculty only found at OSU.
• The total value of this package can exceed $78,000 per year.

Items not covered by the GRA package include room and board, textbooks, OSU student fees, and 15% of student's health insurance premiums (total approximately $500/semester). These expenses are paid by payroll deduction—roughly $125 per month during a semester—allowing the fees to be dispersed over the course of the semester.

GRA openings
A faculty member submits a proposal to a funding source—industry, government agency, etc.—to research a subject of interest to the funding source. To carry out the research the faculty member serves as the "principal investigator" and brings into his/her research group GRA-funded students to assist with the project. Project funding is awarded to our faculty throughout the year. Thus as GRA openings become available they will be posted to our website under Faculty & Research. A typical year sees 15-30 openings in the Autumn; 2-10 each in Spring and Summer semesters.

A number of GRA-supporting research projects are expected to be available in the MSE and WE graduate programs in areas such as:

• nanotechnology
• electronic, optical, and magnetic materials
• biomaterials
• joining/welding technology
• environmental and energy storage materials
• emergent materials
• advanced characterization
• computational materials research
• additive manufacturing
• corrosion studies and corrosion prevention
• membranes for chemical technology
• sensor technology
• materials manufacture
• composites
• processing and structure-property relationships in structural materials

Finding an advisor
We do not assign new students to a research project. Instead, we prefer to have the students and faculty contact each other to discuss available projects. The faculty member with GRA funding will
serve as both the research and academic advisor for the student during the degree. Therefore we feel it is important for both to have an opportunity to discuss the research before committing to work together. Prior to arriving on campus, during the weeks leading up to the term, the student is to contact faculty who have available GRA positions. The student should discuss the research project, background requirements, stipend level, etc.

While our listing of GRA openings will be updated as new research funding is secured by our faculty, new students are encouraged to contact any MSE-WE faculty regarding GRA availability. Faculty who share a new student’s research interests may simply have not yet updated the listing on the web site (see Faculty & Research for listing by research area). While every effort is made to connect a student to a project in his/her field, the new student should understand that it is the project that sets the scope of the research and provides the on-going funding for the degree.

**By the start of the first semester**

Prior to arriving at Ohio State the new student is encouraged to contact our faculty and explore available research projects (Faculty & Research). Joining a project before the start of the term will permit the student to begin thesis research immediately and assure that GRA funding will continue in subsequent semesters. Academic and living costs, as well as the topic of the dissertation, will come from this research funding. Under typical circumstances—given satisfactory academic and research performance and sufficient project funds—GRA support will continue for the remainder of the degree. In past semesters, it has been very typical for new students to be able to secure GRA funding well before arrival or even shortly before the start of the semester.

**By the start of the second semester**

If by the start of the first semester a new student has not secured GRA-funding, s/he may be asked to take on administrative (GAA) or teaching assistant (GTA) duties during the first term. This single-semester GAA/GTA funding will provide the same tuition support and stipend level as was stated in the MSE Department offer letter. During the first semester the student is to continue seeking GRA funding and join a research group no later than the end of his/her first semester. Without a GRA position in place for the subsequent semester all academic and living expenses will be the responsibility of the student until a GRA position is secured.

**On-going expectations**

The research project provides funding for the student's tuition expenses and stipend, as well as payment of thesis research costs. Therefore, the GRA-funded student is expected to make satisfactory progress on the research project during his/her time in the department. Along with research progress, it is expected that the student make satisfactory academic progress toward his/her degree as well.

GRA positions in the department hold a 50% employment appointment with the university. This means that a student's research activities will typically occupy, on average, 20 hours per week, thus allowing time for academic pursuits. GRA’s are required to enroll as full-time graduate students per Graduate School rules.

The student is to speak with his/her advisor about any additional expectations including work schedules, ill time, scheduling time-off, etc. A GRA-funded student is required to register for research credits under his/her advisor in the form of MSE 6/8999 or WE 6/8999 during each term of enrollment.

**Questions?** Please feel free to contact Mark Cooper, MSE-WE Graduate Studies Coordinator, with any questions you might have (614-292-7280, cooper.73@osu.edu).

View GRA openings at mse.osu.edu/faculty-research/gra-positions
## Summary of GRA financial benefits

### Costs paid by the GRA funding annually

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly stipend (12 month cycle)</td>
<td>$2,364/mo paid throughout 12 month period</td>
</tr>
<tr>
<td><strong>Minimum annual stipend = $28,368 per year</strong></td>
<td></td>
</tr>
<tr>
<td>Tuition costs based on AY 20-21 (“academic fees”)</td>
<td>Full-time fees and non-Ohio resident fee</td>
</tr>
<tr>
<td></td>
<td>$5,964.00 + $12,358 = $18,322</td>
</tr>
<tr>
<td></td>
<td><strong>per AU &amp; SP semester (each)</strong></td>
</tr>
<tr>
<td></td>
<td>$2,982.00 + $6,179.00 = $9,161.00</td>
</tr>
<tr>
<td></td>
<td><strong>per SU semester</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Total annual tuition provided = $45,805.00</strong></td>
</tr>
<tr>
<td>Health Insurance Premium assistance</td>
<td>$1,683 each AU &amp; SP semester (no fee in SU)</td>
</tr>
<tr>
<td><em>(see shi.osu.edu, based on single student rate)</em></td>
<td>85% ($1,430.55) is paid by the GRA in both AU &amp; SP semester</td>
</tr>
<tr>
<td></td>
<td><strong>Total Health Insurance Premiums = $2,861.10</strong></td>
</tr>
<tr>
<td>Learning Technology Fee</td>
<td>$255.00 each AU &amp; SP semester; $170 per SU semester</td>
</tr>
<tr>
<td></td>
<td><strong>Total Learning Technology fees = $680.00</strong></td>
</tr>
<tr>
<td>Research costs (materials, lab equipment time, supplies, etc.)</td>
<td>Paid by the GRA funding</td>
</tr>
<tr>
<td>Conference travel assistance</td>
<td>Paid by the GRA funding</td>
</tr>
<tr>
<td><strong>Total value to the student</strong></td>
<td><strong>Can exceed $78,000 per year</strong></td>
</tr>
<tr>
<td></td>
<td>Over the course of a five year PhD this value is nearly $400,000</td>
</tr>
</tbody>
</table>

### Fees for which the student is responsible

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student-related university fees *</td>
<td>$248.40 each AU and SP semester</td>
</tr>
<tr>
<td></td>
<td>$211.20 per SU semester</td>
</tr>
<tr>
<td>Health Insurance Premium (15%) **</td>
<td>$252.45 each AU and SP semester (no fee in SU)</td>
</tr>
<tr>
<td><strong>Semester totals (20-21 AY, est)</strong> ***</td>
<td>$500.85 each AU and SP semester</td>
</tr>
<tr>
<td></td>
<td>$211.20 per SU semester</td>
</tr>
<tr>
<td>Student Legal Services Fee (optional)</td>
<td>$40 per year</td>
</tr>
</tbody>
</table>

* Student-related fees permit the student access to university activities and assets: Student Activity ($37.50), Student Union ($74.40), Recreation ($123), COTA Bus Service ($13.50). Estimates based on 20-21 fees, see: http://registrar.osu.edu/FeeTables/MainFeeTables.asp

** A student remaining on a parent’s insurance does not pay this fee; the student opts out of OSU student insurance and, by doing so, will not pay this 15% premium. Premium assistance is provided for the student holding the GRA; insurance for spouse and/or dependents available for additional cost. By paying the premium in SP term a student will be automatically covered during SU term at no additional cost (see shi.osu.edu).

*** This amount is payroll-deducted from each of the four monthly paychecks during a semester (approx. $125 per pay); the student is not required to pay these amounts in full at the start of a semester.
Master's and Ph.D.
Graduate Degree Guidelines
- Materials Science and Engineering -

Master's degree programs give students the opportunity to gain additional knowledge and necessary skills in a field in order to engage in research and other scholarly activities, to teach, and to become practitioners. At this university, master’s degree programs consist of a coherent pattern of courses and other educational experiences, a Master's Examination, and, in many cases, a thesis or its equivalent.

The student’s advisor is to agree on all course work taken by the student prior to enrolling.

Average course load (full-time student):
- MS without Thesis: two to four graded courses per semester (i.e., 4-10 credits), plus misc. S/U credits as required.
- MS with Thesis: two to three graded courses per semester (4-8 credits), plus S/U credits in MSE 7895 & 6999

Average time to degree:
- MS without Thesis: four to six semesters or 1.5-2 years
- MS with Thesis: six to ten semesters or 2-2.5 years

Doctoral degree programs give students the opportunity to achieve a high level of scholarly competence and to develop the capacity to contribute to the knowledge of their field. At this university, doctoral degree programs consist of a coherent pattern of courses and other educational experiences, a Candidacy Examination, a dissertation, and a Final Oral Examination.

The student’s advisor is to agree on all course work taken by the student prior to enrolling.

Average course load (full-time student):
- Two to three graded courses per semester (4-8 credits), typically taken during the student’s first two to three years in the program. The remaining semesters are typically spent fully focusing on research in support of the dissertation.

Average time to degree (following BS degree):
- 12 to 16 semesters or 4-5.5 years
Master’s Degree with Thesis—MSE

I 30 total graduate credit hours are required for an MS degree.

A Of these 30 hours, at least 15 must be graded graduate level courses.
   1 Of these 15 hours in MSE, at least 9 credit hours must be taken at the 6000 level or greater in MSE.
   2 The remaining 6 credit hours of graded graduate level course work may be taken within MSE or come from relevant non-MSE credits.

B At least 15 credit hours may come from other courses, besides those listed in A1&2, to bring the total graduate credit hours to 30 or greater.
   1 Of these 15 hours, at least 3 and no more than 4 credit hours of MSE 7895 (Graduate Seminar and Colloquium), all with Satisfactory grade, may apply.
   2 Of these 15 hours, credit for at least two semesters of Instructional Assistant service earned while assisting in the instruction of the undergraduate studies program.
   3 Of these 15 hours, at least 10 credit hours are to be from MSE 6999 (Research in Materials Science and Engineering).

II Presentation and defense of an acceptable thesis.

Master’s Degree without Thesis—MSE

I 30 total graduate credit hours are required for an MS degree.

A Of these 30 hours, at least 18 credit hours must be graded graduate level courses.
   1 Of these 18 hours, at least 12 credit hours must be taken in MSE at the 6000 level or above.
   2 The remaining credit hours may be taken within the department or outside MSE—if taken outside MSE, it is understood that all chosen courses (at most 6 credits) are to be related to the student’s area of materials study.

B At least 12 hours of the 30 credit hours may come from other courses, besides those listed in A1&2, to bring the total graduate credit hours to 30 or greater.
   1 Of these 12 credit hours, at least 3 and no more than 4 credit hours of MSE 7895 (Graduate Seminar and Colloquium), all with Satisfactory grade, will count toward the requirement.
   2 Credit for MSE 6193.01 (Individual Study) may be earned toward fulfillment of this 12 credit hour minimum during completion of the written document.
   3 Public presentation of an oral seminar on a technical topic in final term of enrollment, if assigned by the MS Committee.

II Submission to the student’s MS examination committee of a written document comprising, for example, a critical review of a technical topic. MSE 6193.01 credit is earned during its preparation. PRIOR approval of the topic by the examining committee is REQUIRED. Approval of the topic is to take place before the end of the second semester of study in the program.
Ph.D. Degree—MSE

I 80 total graduate credit hours are required for a Ph.D. degree.

A Of these 80 hours, at least 18 must be graded graduate level courses.

1 Of these 18 credit hours, three “Core Courses” are required (MSE 6730, 6737, and 6747). They must be taken within three academic terms of the student joining the MSE department (“academic terms” being Autumn and Spring). The three Core Courses are worth a total of 9 credit hours.

2 The remaining 9 graded graduate level credit hours must come from MSE courses at the 6000 level or above. Students may petition the GSC to accept suitable alternate courses.

B At least 62 graduate credit hours may come from other relevant graduate-level credits to bring the total graduate credit hours to 80.

1 Of these 62 credit hours, if the student has no previous degree in Materials Science and Engineering, MSE 5605 (Graduate-Level Introduction to MSE) must be taken no later than the first academic term it is offered after the student has joined the MSE department.

2 At least 3 (2 to be completed before the Candidacy Exam) and up to 8 credit hours of MSE 7895 (Graduate Seminar and Colloquium), count towards this 62 credit hour minimum, provided they are completed with Satisfactory grade.

3 Of these 62 credit hours, credit is required for at least 2 semesters of Instructional Assistant service earned while assisting in the instruction of the undergraduate studies program.

4 Of the 62 credit hours, at least 10 credit hours are to be from MSE 6/8999 (Research in MSE).

II Successful completion of the Qualifying Exam. Students qualify for Ph.D. Candidacy by completing the three MSE Core Courses (MSE 6730, 6737, and 6747) and, when required, MSE 5605, having earned a minimum grade of B in each. Grades below B require a Qualifying Exam for that sub-B course. The Qualifying Exam must be taken within four academic terms of the student joining the MSE department.

III Successful completion of the Candidacy Examination

- The written portion consists of a 15-page research proposal/literature review.

- The oral portion is a defense and discussion of this document.

IV Dissertation Overview. Public presentation of the student’s research progress to his/her Dissertation Committee. The student’s Dissertation Committee provides advice throughout the completion of the dissertation. Must register for MSE 8000 in Overview term.

IV Presentation and defense of an acceptable dissertation.

- The dissertation is a scholarly contribution to knowledge in the student’s area of specialization. Through it, the student is to demonstrate a high level of knowledge and the capacity to function as an independent scholar.

- The Final Oral Exam tests originality, independence of thought, the ability to synthesize and interpret, and the quality of research presented.
Master's and Ph.D.
Graduate Degree Guidelines
- Welding Engineering -

Master's degree programs give students the opportunity to gain additional knowledge and necessary skills in a field in order to engage in research and other scholarly activities, to teach, and to become practitioners. At this university, master’s degree programs consist of a coherent pattern of courses and other educational experiences, a Master's Examination, and, in many cases, a thesis or its equivalent. 

The student's advisor is to agree on all course work taken by the student prior to enrolling.

Average course load (full-time student):
- MS without Thesis: two to four graded courses per semester (i.e., 4-10 credits), plus misc. S/U credits as required.
- MS with Thesis: two to three graded courses per semester (4-8 credits), plus misc. S/U credits as required.

Average time to degree (full-time student):
- MS without Thesis: four to six semesters or 1.5-2 years
- MS with Thesis: six to ten semesters or 2-2.5 years

Doctoral degree programs give students the opportunity to achieve a high level of scholarly competence and to develop the capacity to contribute to the knowledge of their field. At this university, doctoral degree programs consist of a coherent pattern of courses and other educational experiences, a Candidacy Examination, a dissertation, and a Final Oral Examination.

The student's advisor is to agree on all course work taken by the student prior to enrolling.

Average course load (full-time student):
- Two to three graded courses per semester (4-8 credits), typically taken during the student’s first two to three years in the program. The remaining semesters are typically spent fully focusing on research in support of the dissertation.

Average time to degree (following BS degree, full-time student):
- 12 to 16 semesters or 4-5.5 years
Master’s Degree with Thesis—WE

I 30 total graduate credit hours are required for an MS with Thesis degree.

A Of these 30 hours, at least 18 must be graded graduate level courses.

1. Of these 18 credits, at least 15 credit hours must be taken in WE with at least 6 taken at the 7000 level or greater. This permits up to 3 credits to come from relevant non-WE graduate course work.

2. Of these 18 credits, at least four courses from the WE Core Courses (at right). At least two courses must come from two different Primary categories.

B At least 12 credit hours may come from other courses, besides those listed above, to bring the total graduate credit hours to 30 or greater. Required enrollment:

1. Enroll in WE 7895 (Graduate Seminar and Colloquium) every Autumn and Spring.

2. Credit is required for at least 1 semester of Instructional Assistant service earned while assisting in the instruction of the undergraduate studies program.

3. Of these 12 hours, at least 10 credit hours are to come from WE 6999 (Research in Welding Engineering).

C Public presentation or publication—at least one is required before graduation.

II Presentation and defense of an acceptable thesis.

Master’s Degree without Thesis—WE

I 30 total graduate credit hours are required for an MS without Thesis degree.

A Of these 30 hours, at least 24 must be graded graduate level courses.

1. Of these 24 credits, at least 20 credit hours must be taken in WE. This permits up to 4 credits to come from relevant non-WE graduate course work.

2. Of these 20 credits, at least four courses from the WE Core Courses (at right). At least two courses must come from two different Primary categories.

B At least 6 credit hours may come from other courses, besides those listed above, to bring the total graduate credit hours to 30 or greater. Required enrollment:

1. WE 7193.01—4 to 6 credits earned while writing the written examination document.

2. Enroll in WE 7895 (Graduate Seminar and Colloquium) every Autumn and Spring (on-campus students).

3. Credit is required for at least 1 semester of Instructional Assistant service earned while assisting in the instruction of the undergraduate studies program (on-campus students).

II Final written examination (see I B 1 above)—student also provides an oral presentation to MS committee on topic of written document.
Ph.D. Degree—WE

I 80 total graduate credit hours are required for a Ph.D. degree.

A Of these 80 hours, at least 30 must be graded graduate level courses.
   1. Of these 30 credits, at least 21 credit hours must be taken in WE at the 7000 level or greater. This permits up to 9 credits to come from relevant non-WE graduate course work.
   2. Of these 21 credits, at least four courses from the WE Core Courses (at right). At least two courses must come from two different Primary categories.
      - To qualify to take the Candidacy Examination at student must earn a 3.0 or greater in the four Core courses taken.

B At least 50 graduate credit hours may come from other courses, besides those listed in A1-2 to bring the total graduate credit hours to 80.
   1. Of these 50 credits, all full-time students are to register for WE 7895 (Graduate Seminar and Colloquium) every AU & SP semester, except in the semester of graduation. Part-time students are exempted from this requirement.
   2. Of these 50 credits, a minimum of 20 credits are to come from WE 6/8999 (Research in Welding Engineering). All thesis / dissertation work (WE 6/8999) and research plans are to be approved by the student's advisor.
   3. Credit is required for at least 2 semesters of Instructional Assistant service earned while assisting in the instruction of the undergraduate studies program.

III Successful completion of the Candidacy Examination.
   - The written portion consists of a 20-page Critical Literature Review.
   - The oral portion is a defense and discussion of this document.

IV Dissertation Overview. Public presentation of the student’s research progress to his/her Dissertation Committee to occur at least six months before Final Examination. The student’s Dissertation Committee provides advice throughout the completion of the dissertation.

V Publication requirement--The student is to generate a minimum of two publications which are accepted in peer-reviewed journals. If impact factor is 4 or greater, only 1 publication is required.

VI Presentation and defense of an acceptable dissertation.
   - The dissertation is a scholarly contribution to knowledge in the student's area of specialization. Through it, the student is to demonstrate a high level of knowledge and the capacity to function as an independent scholar.
   - The Final Oral Exam tests originality, independence of thought, the ability to synthesize and interpret, and the quality of research presented.
Introduction to Engineering Materials U 3
Introduction to the properties (mechanical, electrical, thermal, diffusive, degradative, magnetic, optical), structure, and processing of engineering materials, including ceramic, metals, polymers, biological, and composite materials.
Prereq: Physics 1250 or 1260, Math 1151 or 1161, and Chemistry 1210 or 1250 or 1910; or permission of instructor.

Group Studies in Materials Science and Engineering U 0 - 6
Special topics in MSE not offered in other courses. Repeatable to a maximum of 12 cr hrs or 6 completions.

Structure and Characterization of Materials U 3
Prereq: Physics 1250 or 1260, Math 1151 or 1161, and Chem 1210 or 1250; and enrollment as MatScEn-BS student; or permission of instructor. Not open to students with credit for both 341 and 342.

Thermodynamics of Materials U 3
Fundamental basis of three laws of thermodynamics, phase equilibria, reaction equilibria, solution theory, and phase diagrams and electrochemistry.
Prereq: Physics 1250 or 1260, Math 1151 or 1161, and Chem 1210 or 1250; and enrollment as MatScEn-BS student; or permission of instructor. Not open to students with credit for both 401 and 525.

Modeling and Simulation Lab I U 3
A modeling and simulation laboratory appropriate to sophomore-level study in materials science and engineering.
Prereq: Physics 1250 or 1260, Math 1151 or 1161, and Chem 1210 or 1250; and enrollment as MatScEn-BS student; or permission of instructor.

Structure and Characterization Lab U 2
Companion laboratory course to MatScEn 2241. Experiments on X-ray diffraction, scanning electron microscopy, optical microscopy, and stereology with applications. Statistical treatment of data and technical reporting.
Prereq: Physics 1250 or 1260, Math 1151 or 1161, and Chem 1210 or 1250; and enrollment as MatScEn-BS student; or permission of instructor. Not open to students with credit for 282.

Transformation and Processing of Materials U 3
Introduction to transformations, and the relationship between microstructure, properties, and processing in metals, ceramics, semiconductors, and polymers.
Prereq: 2251, and enrollment as MatScEn-BS or WeldEng-BS major; or permission of instructor.

Transport Phenomena and Kinetics U 3
Provides students with concepts related to transport phenomena and kinetics as applied to processing of metals, ceramics, polymers, and composite materials.
Prereq: 2010 and 2241; and Math 2177 or 2415; or 2174; and enrollment as MatScEn-BS student; or permission of instructor.

Professional Practice in Industry U ½ - 3
Preparation of a comprehensive report based on employment experience in a co-op or job in industry. Repeatable to a maximum of 8 cr hrs or 3 completions. This course is graded S/U.

Individual Studies in Materials Science & Engineering U ½ - 6
Investigations in areas of advanced non-thesis research. Library and/or research investigations under the direction of instructors. Comprehensive report required.
Prereq: Permission of instructor. Repeatable to a maximum of 12 cr hrs or 12 completions. This course is graded S/U.

Individual Studies in Materials Science & Engineering U ½ - 6
Investigations in areas of advanced non-thesis research. Library and/or research investigations under the directions of instructors. Comprehensive report required.
Prereq: Permission of instructor. Repeatable to a maximum of 12 cr hrs or 12 completions.

Introduction to the Mechanical Behavior of Materials U 3
Survey of the mechanical response of solids to forces and stresses. Response studied include elastic, viscoelastic, plastic deformation and fracture.
Prereq: 2010, and MechEng 2020 or 2040; and enrollment as MatScEn-BS student; or permission of instructor.

Electronic Properties U 3
Introduction to structure, property, and applications of electronic materials. Includes electronically and ionically conducting materials, dielectrics, and optical and magnetic materials.
Prereq: 2010; and Math 1151 or 1161; and Physics 1251 or 1261; and enrollment as MatScEn-BS student; or permission of instructor. Not open to students with credit for 371.

Modeling and Simulation Lab II U 2
Modeling and simulation techniques appropriate to junior-level study in materials science and engineering.
Prereq: 2321, 3141, and 3151, and enrollment as MatScEn-BS student; or permission of instructor.

Materials Science and Engineering Lab I U 2
Laboratory experiments related to materials processes and properties. Introduction to experimental techniques used in materials fields. Data analysis, presentation, and technical writing skills.
Prereq: 2331, and enrollment as MatScEn-BS major; or permission of instructor. Not open to students with credit for both 581.01 and 581.02.

Materials Science and Engineering Lab II U 2
Laboratory experiments related to materials application and performance. Advanced experimental techniques and analysis in these areas. Technical writing skills at fully professional level.
Prereq: 2241, 2331, and 2251; and enrollment as MatScEn-BS student; or permission of instructor. Not open to students with credit for both 581.02 and 581.03.

Materials Science and Engineering Laboratory for Welding Engineering Students U 2
Lab experiments related to heat treating, casting, welding, materials characterization, and properties. Introduction to experimental techniques in materials science. Development of technical writing skills.
Prereq: WeldEng 3001 and 3601; and enrollment as WeldEng-BS major; or permission of instructor. Not open to students with credit for 581.04. Not open to students majoring in MatScEn.

Biological Response to Biomaterials U 3
The biological response to biomaterials implanted within the human body.
Prereq: 2010, and Biology 1113 or 2100; or permission of instructor. Not open to students with credit for 645 and 646.

Materials Selection U 2
Systematic and quantitative strategies for selecting materials and processes as a foundation for designing with materials.
Prereq: 2241, 2331, 2251, 2321, and enrollment as MatScEn-BS major; or permission of instructor. Not open to students with credit for 600.

Individual Studies in Materials Science & Engineering U ½ - 6
Investigations in areas of advanced non-thesis research. Library and/or research investigations under the directions of instructors. Comprehensive report required.
Prereq: Permission of instructor. Repeatable to a maximum of 12 cr hrs or 12 completions. This course is graded S/U.

Individual Studies in Materials Science & Engineering U ½ - 6
Investigations in areas of advanced non-thesis research. Library and/or research investigations under the directions of instructors. Comprehensive report required.
Prereq: Permission of instructor. Repeatable to a maximum of 12 cr hrs or 12 completions.

Group Studies in Materials Science and Engineering U 0 - 6
Special topics in Materials Science and Engineering. Repeatable to a maximum of 12 cr hrs or 8 completions.

Modeling and Simulation-Based Design U 3
Practical modeling and simulation techniques appropriate to senior-level design in materials science and engineering.
Prereq: 2321, 3321, and enrollment as MatScEn-BS major; or permission of instructor.

Design and Professional Practice I U 3
An in-depth design project to foster independent thinking and to develop problem-solving skills. Design of experiments, applied statistics, presentation and communication skills will be discussed.
Prereq: 3141, 3151, and 3331. Prereq or concord: 3261, 3271, or 3332, and enrollment as MatScEn-BS major; or permission of instructor.

Design and Professional Practice I, Biomedical U 3
First course in a two-course MSE Senior Design sequence with a biomedical engineering emphasis. Introduction to design principles; challenges of biomedical device design; projects focus on helping persons with disabilities.
Prereq: 3141, 3151, 3331, and enrollment as MatSEng-BS major. Prereq or concord: 3261, 3271, or 3331.

Design and Professional Practice II U 3
An in-depth design project to foster independent thinking and to develop problem-solving skills. Design of experiments, applied statistics, presentation and communication skills will be discussed.
Prereq: 4381.01, and enrollment as MatScEn-BS major; or permission of instructor.

Design and Professional Practice II, Biomedical U 3
Second course in a two-course MSE Senior Design sequence with a biomedical engineering emphasis. Applying design principles; challenges of biomedical device design; engineering and testing devices that focus on helping persons with disabilities.
Prereq: 4381.02, and enrollment as MatSEng-BS major; or permission of instructor.

Undergraduate Research U ½ - 3
Supervised undergraduate research on various topics. Repeatable to a maximum of 6 cr hrs or 6 completions.

Undergraduate Research U ½ - 3
Supervised undergraduate research on topics in Materials Science & Engineering.
Prereq: Permission of instructor. Repeatable to a maximum of 6 cr hrs or 2 completions.
Materials Science and Engineering

5193.01 Individual Studies in Materials Science & Engineering U G 0 - 6
Investigations in areas of advanced non-thesis research. Library and/or research investigations under the directions of instructors. Comprehensive report required. 
Prereq: Permission of instructor. Repeatable to a maximum of 12 or hrs or 12 completions. This course is graded S/U.

5193.02 Individual Studies in Materials Science & Engineering U G 0 - 6
Investigations in areas of advanced non-thesis research. Library and/or research investigations under the directions of instructors. Comprehensive report required. 
Prereq: Permission of instructor. Repeatable to a maximum of 12 or hrs or 12 completions.

5194 Group Studies in Materials Science & Engineering U G 0 - 6
Investigations in areas of advanced non-thesis research. Library and/or research investigations under the directions of instructors. Comprehensive report required. Repeatable to a maximum of 12 cr hrs or 8 completions.

5237 Photovoltaics Laboratory U G 4
Introduce student to basic techniques for fabrication and measurement of photovoltaic cells. Learn computer tools for simulation of photovoltaic cell characteristics. Obtain practical experience with contact and series resistance, spectral sensitivity, open circuit voltage, short circuit current, and quantum efficiency of photovoltaic devices and test structures fabricated in lab. 
Prereq: 3271 or ECE 3030, and enrollment in ECE or MatScEn major; or Grad standing in Engineering, Biological Sciences, or Math and Physical Sciences. Cross-listed in ECE.

5321 Computational Thermodynamics and Kinetics U G 2
Comprehensive background on computational thermodynamics and kinetics. Includes focus on CALPHAD (Calculation of Phase Diagram) methodology. 
Prereq: 2251 and 3151 or equivs, or Grad standing in MatScEn or WeldEng; or permission of instructor. Cross-listed in WeldEng 4121 and 7121.

5431 Advanced Metals Laboratory U G 1
Advanced laboratory covering various topics in metallic materials. 
Prereq: 2241, 3231, 3141, 3261, and 3332. Prereq or concur: 5441 or 5451; or permission of instructor. Not open to students with credit for 669, or to Grad students enrolled in MatScEn or WeldEng.

5441 Physical Metallurgy U G 3
Physical metallurgy of ferrous and non-ferrous alloys. Emphasis on alloy design, processing and structure-property relations. 
Prereq: 2251 and 3151 or equivs, or Grad standing in MatScEn or WeldEng; or permission of instructor. Not open to students with credit for both 661 and 663.

5451 Molten Metal Processing U G 3
An advanced class in application of thermodynamics, kinetics, and macro-transport phenomena to primary metals production, refining, and solidification processing. 
Prereq: 2251 or 3151; or Grad standing; or permission of instructor. Not open to students with credit for 667, 668, 5451, ISE 5502, or 651.02. Cross-listed in ISE 5502.

5531 Ceramics Processing Laboratory U G 1
Laboratory experiments involving synthesis/fabrication and characterization of high performance technical ceramics. 
Prereq: 3141, 3261, 3271, 3332, and enrollment as MatScEn-BS major; or Grad standing; or permission of instructor. Not open to students with credit for 619.

5532 Electronic, Optical, and Magnetic Properties Laboratory U G 1
Correlates electronic, optical, and magnetic properties of materials with structure, composition, and microstructure. Examples include resistivity, the Hall effect, and ferromagnetism/ferroelectric hysteresis. 
Prereq: 3141, 3261, 3271, 3332, and enrollment as MatScEn-BS major student; or Grad standing or permission of instructor. Not open to students with credit for 679.

5551 Ceramic Processing U G 3
Overview of ceramics processing, including essential topics of: powder synthesis/characterization, colloidal/sol-gel processing, shaping/solidification, sintering, microstructure development and nanoceramics, and thin films/coating. 
Prereq: 3141, 3151, and enrollment as MatScEn-BS major; or Grad standing; or permission of instructor. Not open to students with credit for 615.

5552 Nanoscale Synthesis and Processing of Electronic U G 3
Prereq: 3141 and 3271, or permission of instructor. Not open to students with credit for 676.

5571 Electroceramics U G 3
Functional ceramics covering electrical, magnetic and optical properties of oxides. Emphasis is on the processing-microstructure-property correlation. 
Prereq: 3271, or permission of instructor. Not open to students with credit for 614.

5571.71 Electroceramics I: Electronic and Ionic Conductors U G 1½
Functional ceramic oxides covering electronic and ionic conductors and their applications in devices. Emphasis on the processing-microstructure-property correlation. 
Prereq: 3271, or permission of instructor. Not open to students with credit for 5571.

5571.72 Electroceramics II: Dielectric, Magnetic, and Optical Ceramics U G 1½
Dielectric, Magnetic, and Optical Ceramics and their applications in devices. Emphasis on the processing-microstructure-property correlation. 
Prereq: 3271, or permission of instructor. Not open to students with credit for 5571.

5572 Materials for Energy Technology U G 3
Structure property relationships of materials in energy applications. Photovoltaic materials, solid state photonic materials, electrochemical devices such as batteries, fuel cells and chemical sensors, superconductors, memory and nuclear materials. 
Prereq: 2241, and 3271 or ECE 2300; and enrollment as MatScEn-BS major; or Grad standing or permission of instructor.

5605 Quantitative Introduction to Materials Science U G 3
A quantitative survey of the key elements related to the processing, structure and properties of materials. Structural materials and core aspects are emphasized. Intended for MS/PhD students enrolled in MatScEn who come from a non-MatScEn background. 
Prereq: Grad standing in MatScEn or WeldEng; or permission of instructor. Not open to students with credit for both 610, 6605, or 665, or to students enrolled in MatScEn-BS.

5611 Materials in Medicine U G 3
The materials science of plastics, metals and ceramics currently used to replace or supplement tissues within the human body. 
Prereq: 2010 and 3611; or Grad standing; or permission of instructor. Not open to students with credit for both 645 and 646.

5631 Biomaterials Laboratory U G 1
A laboratory experience in the processing and characterization of biomaterials used for the replacement of human tissues. 
Prereq or concur: 5611 or 5641; or permission of instructor. Not open to students with credit for 649.

5641 Structure-Property Relationships of Polymers U G 3
An understanding of the structure/property relationships that drive the continued expansion of polymers into a wide array of applications. 
Prereq: 2010, CPPHR 2.0 or higher, and rank 3 or 4 in Engineering; or Grad standing; or permission of instructor. Not open to students with credit for both 642 and 643.

5651 Biomaterials Processing U G 3
The relationship between the processing of biomaterials - metals, polymers and ceramics - and the impact that these steps have on final biomedical properties. 
Prereq: 5611 or 5641; or permission of instructor.

5711.70 Introduction to Composites U G 1½
In this seven-week course, students will gain the theoretical background as well as practical knowledge of the structure and properties of ceramic, metal, and polymer matrix composites. 
Prereq: 3261, or Grad standing, or permission of instructor. Not open to students with credit for both 643 and 644.

5761.71 Mechanical Behavior of Crystalline Solids at Lower Temperatures in Materials Science and Engineering U G 1½
Strength and deformation mechanisms in crystalline solids at low temperatures. 
Prereq: 3261 or 3332; or Grad standing; or permission of instructor. Not open to students with credit for MatScEn 5761.

5761.72 Mechanical Behavior of Crystalline Solids at High Temperatures in Materials Science and Engineering U G 1½
Strength and deformation mechanisms in crystalline solids at high temperatures. 
Prereq: 3261 or 3332; or Grad standing; or permission of instructor.

5763.70 Fracture and Fatigue of Engineering Materials U G 1½
This seven week course will provide a background in fracture and fatigue with a survey of material-specific mechanisms. 
Prereq: 3261, or Grad standing; or permission of instructor. Not open to students with credit for 5763.

5774 Polymer Membranes U G 3
Membrane separation mechanisms, transport models, permeability computations/measurements, membrane materials/types/modules, membrane contactors/reactions, and applications. 
Prereq: ChBE 3508 (509), or Grad standing; or permission of instructor. Not open to students with credit for 774 or ChBE 774. Cross-listed in ChBE.
Materials Science and Engineering

5951 Corrosion and Failure Analysis U G 3
Covers fundamentals of environmental degradation of materials, corrosion phenomenology and corrosion prevention strategies. Also methodologies for root cause analysis of failed components.
Prereq: Sr or Grad standing in Engineering, or permission of instructor.

5971 Solid State Science U G 3
In-depth theory of electronic structure of materials as related to the materials' atomistic structure. The origins of the mechanical, optical and magnetic properties are discussed.
Prereq: 2010 and 5271; or permission of instructor.

6193.01 Individual Studies in Materials Science and Engineering G 0 - 6
Investigations in areas of advanced non-thesis research. Library and/or research investigations under the directions of instructors. Comprehensive report required.
Prereq: Permission of instructor. Repeatable to a maximum of 12 cr hrs or 12 completions. This course is graded S/U.

6193.02 Individual Studies in Materials Science & Engineering G 0 - 6
Investigations in areas of advanced non-thesis research. Library and/or research investigations under the directions of instructors. Comprehensive report required.
Prereq: Permission of instructor. Repeatable to a maximum of 12 cr hrs or 12 completions.

6194 Group Studies in Materials Science and Engineering G 0 - 6
Special topics in Materials Science and Engineering. Repeatable to a maximum of 12 cr hrs or 8 completions.

6295 Superconducting Materials and Properties G 2
Introduction to superconducting materials and phenomena. It will focus on the description of various materials and their properties in terms of basic superconducting phenomena, and the influence of materials-based properties on these phenomena.
Prereq: Grad standing in Material Science & Engineering, Welding, or Engineering; or Math and Physical Sciences; or permission of instructor.

6700 Essentials of Materials Science for High School Educators G 2
Provides academic background and quantitative examples to the demonstrations and applications in the ASM Materials Foundation Materials Camps for Teachers. This course requires students in this class to deploy related content in their high school classroom settings.
Prereq: Graduate Non-Degree status, or permission of instructor.

6715 Principles of the Characterization of Materials G 2
Fundamentals of beam-solid interactions and their application to characterizing the structure and composition of materials. The emphasis of this course will be on techniques utilizing X-ray and electron probes.
Prereq: Grad standing in MatScEn or WeldEng, or permission of instructor. Not open to students with credit for 715.

6730 Thermodynamics of Materials – PhD Core G 3
Thermodynamics of mixtures and phase equilibria relevant to metallurgy and materials science.
Prereq: Grad standing or permission of instructor. Not open to students with credit for 730.

6735 Corrosion Science and Materials Electrochemistry G 2
Electrochemistry fundamentals, corrosion thermodynamics and kinetics, experimental approaches, corrosion phenomenology, corrosion control strategies, nonmetallic material degradation, electrochemistry of batteries, fuel cells, and electrodeposition.
Prereq: Grad standing in MatScEn or permission of instructor. Not open to students with credit for 735.

6737 Diffusion and Interface Kinetics – PhD Core G 3
Detailed atomic and phenomenological descriptions of rate limiting steps, diffusion, and interface kinetics with applications involving mass transport and phase transitions in the solid state.
Prereq: Grad standing in MatScEn, or permission of instructor. Not open to students with credit for 737.

6740 Practical Scanning Electron Microscopy Laboratory G 2
Provides basic understanding of scanning electron microscopy characterization methods, understanding of sample preparation & compatibility, various imaging modes, and analytical techniques. This course focuses primarily on the practical operation of a scanning electron microscope, and not on its theoretical background.
Prereq: Grad standing; or permission of instructor. This course is graded S/U.

6741 Practical Transmission Electron Microscopy Lab G 2
Transmission Electron Microscopy with emphasis on practical methods.
Prereq: Grad standing; or permission of instructor.

6747 Structure and Defects in Materials – PhD Core G 3
Elements of crystallography, structure and defects in solids.
Prereq: Grad standing in Chem, Engr, or Physics; or permission of instructor.

6756.71 Computational Materials Modeling - Continuum Scale G 1
Practical computational materials modeling and simulation techniques with focus on methods at the continuum scale.
Prereq: Grad standing in MatScEn or permission of instructor. Not open to students with credit for 6756 or 756.

6756.72 Computational Materials Modeling - Atomic Scale G 1
Practical computational materials modeling and simulation techniques with focus on the atomic scale.
Prereq: Grad standing in MatScEn or permission of instructor. Not open to students with credit for 6756 or 756.

6757 Advanced Metallic Materials and Processing G 2
A graduate class in design, processing and simulation of advanced metallic materials including alloys (ferrous and non-ferrous) and metal matrix composites.
Prereq: Grad standing in AeroEng, ISE, MatScEn, MechEng, NuclrEn, or WeldEng; or permission of instructor. Not open to students with credit for ISE 6557. Cross-listed in ISE 6557.

6758 Advanced Metallic Materials and Processing G 2
A graduate class in design, processing and simulation of advanced metallic materials including alloys (ferrous and non-ferrous) and metal matrix composites.
Prereq: Grad standing in AeroEng, ISE, MatScEn, MechEng, NuclrEn, or WeldEng; or permission of instructor. Not open to students with credit for ISE 6557. Cross-listed in ISE 6557.

6759 Mechanical Behavior of Materials G 2
Mechanical response of materials to loads and deformation.
Prereq: Grad standing in MatScEn, or permission of instructor. Not open to students with credit for 765.

6777 Electronic Properties of Materials G 2
In-depth analysis of the structure - property relationships and application of materials in electronics, optics and magnetics.
Prereq: Grad standing in Engineering or Science or permission of instructor. Not open to students with credit for 777.

6778 Magnetic Materials G 2
This course teaches the basic properties of magnetic materials in a wide class of materials including metals, insulators, semiconductors. The relationships between structure, composition, processing, and magnetic properties will be reviewed with a special focus on the atomic origins of magnetism and the ability to engineer these mechanisms through alloying or doping, or layered structures.
Prereq: Grad standing in Engineering or Mathematical and Physical Science; or permission of instructor.

6999 Graduate Research in Materials Science and Engineering G ½ - 18
Research for thesis purposes only. Repeatable. This course is graded S/U.

7193.01 Individual Studies in Materials Science and Engineering G 0 - 6
Investigations in areas of advanced non-thesis research. Library and/or research investigations under the directions of instructors. Comprehensive report required.
Prereq: Permission of instructor. Repeatable to a maximum of 12 cr hrs or 12 completions. This course is graded S/U.

7193.02 Individual Studies in Materials Science & Engineering G 0 - 6
Investigations in areas of advanced non-thesis research. Library and/or research investigations under the directions of instructors. Comprehensive report required.
Prereq: Permission of instructor. Repeatable to a maximum of 12 cr hrs or 12 completions.

7194 Group Studies in Materials Science and Engineering G 0 - 6
Special topics in Materials Science and Engineering. Repeatable to a maximum of 12 cr hrs or 8 completions.

7531 Epitaxial Heterostructures G 2
Science and techniques behind thin film growth and engineering for combining different materials, altering chemical composition at the nanometer scale, while controlling defects and strain. Epitaxial crystal growth will be explained. Students will gain an understanding of the kinetics, thermodynamics, and technology involved in epitaxial heterostructures and self-assembled nanostructures.
Prereq: Grad standing. Cross-listed in ECE.

7818 Advanced Topics in Corrosion Science G 2
Advanced topics in corrosion science.
Prereq: 6735. Not open to students with credit for 881.

7835 Point Defects in Crystalline Materials G 2
A thermodynamic and electrochemical treatment of the formation, concentrations, mobilities, and interactions of atomic, ionic, and electronic point defects in materials at high temperatures.
Prereq: 6730 and 6737, or permission of instructor. Not open to students with credit for 835.

7845 Solid Surfaces and Interfaces G 2
Elements of surface and interface science. Thermodynamics, structure, microstructure and kinetics of interfacial phenomena in materials.
Prereq: 6730, 6737, and 6747. Not open to students with credit for 845.
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>7850</td>
<td>Structural Transformations</td>
<td>G 2</td>
<td>Structural transformations in materials with emphasis on basic phenomena. Selected topics will be developed based on classical approaches and recent advances. Prereq: 6730 and 6737. Not open to students with credit for 850.</td>
</tr>
<tr>
<td>7855</td>
<td>Electron Diffraction, Imaging and Spectroscopies</td>
<td>G 2</td>
<td>Advanced topics in characterizing materials using transmission electron microscopy. Topics covered include electron diffraction techniques, important imaging modes, and widely used spectroscopy methods. Prereq: 6715, or permission of instructor. Not open to students with credit for 855.</td>
</tr>
<tr>
<td>7862</td>
<td>Microstructural Elasticity</td>
<td>G 2</td>
<td>Elastic interaction between vacancies, dislocations, faults, grain boundaries, interfaces, precipitates, transforming particles, cracks, and indentations controls material properties, primarily mechanical. Prereq 6765.</td>
</tr>
<tr>
<td>7895</td>
<td>Graduate Seminar in Materials Science and Engineering</td>
<td>G 1</td>
<td>Presentations and discussion by graduate students, outside speakers on thesis research, and current problems in Materials Science and Engineering. Prereq: Grad standing in MatScEn, or permission of instructor. Repeatable to a maximum of 20 cr hrs. This course is graded S/U.</td>
</tr>
<tr>
<td>8000</td>
<td>MSE PhD Dissertation Overview</td>
<td>G 1</td>
<td>Public review of PhD research and committee guidance on dissertation topic. Prereq: Only open to students who have passed the MSE PhD Candidacy Exam. This course is graded S/U.</td>
</tr>
<tr>
<td>8194</td>
<td>Group Studies in Materials Science and Engineering</td>
<td>G 0 - 6</td>
<td>Special topics in Materials Science and Engineering. Repeatable to a maximum of 12 cr hrs or 8 completions.</td>
</tr>
<tr>
<td>8999</td>
<td>Graduate Research in Materials Science and Engineering</td>
<td>G ½ - 18</td>
<td>Research for dissertation purposes only. Repeatable. This course is graded S/U.</td>
</tr>
<tr>
<td>Course Code</td>
<td>Course Title</td>
<td>Credits</td>
<td>Prerequisites</td>
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<tr>
<td>4001</td>
<td>Physical Principles in Welding Processes I</td>
<td>U 4</td>
<td>Study of the application of physical principles in engineering of arc welding processes and equipment. Prereq: 2001 or 3001, and enrollment in the WeldEng-BS major. Prereq or concur: ECE 2300; or permission of instructor.</td>
</tr>
<tr>
<td>4002</td>
<td>Physical Principles in Welding Processes II</td>
<td>U 4</td>
<td>Study of the application of physical principles in engineering of non-arc welding processes and equipment. Prereq: 2001 or 3001, and enrollment in the WeldEng-BS major or MatScEn-BS major; or permission of instructor.</td>
</tr>
<tr>
<td>4012</td>
<td>Resistance Welding Processes</td>
<td>U 3</td>
<td>Addresses the fundamentals, theory, and application of Resistance Welding Processes, with emphasis on processes, equipment, materials, and quality control. Prereq: 4002, and enrollment as WeldEng-BS major; or permission of instructor. Not open to students with credit for 602 or 702.</td>
</tr>
<tr>
<td>4021</td>
<td>Solid-State Welding/Joining</td>
<td>U 3</td>
<td>The welding and joining of materials in the solid state with emphasis on physical processes and metallurgical principles. Prereq: 4002, and enrollment in the WeldEng-BS or MatScEn-BS major; or permission of instructor.</td>
</tr>
<tr>
<td>4023</td>
<td>Brazing and Soldering</td>
<td>U 3</td>
<td>Brazing and soldering processes with emphasis on physical and metallurgical principles, materials, design and application considerations. Prereq: 2001 or 3001 and MatScEn 2251, and enrollment in the WeldEng-BS or MatEng-BS major; or permission of instructor.</td>
</tr>
<tr>
<td>4024</td>
<td>High Energy Density Welding Processes</td>
<td>U 2</td>
<td>Theory and practice of laser, electron beam, and other high energy density welding processes. Prereq: 4001, and enrollment as a WeldEng-BS or MatEng-BS major; or permission of instructor. Not open to students with credit for 704.</td>
</tr>
<tr>
<td>4101</td>
<td>Welding Metallurgy I</td>
<td>U 4</td>
<td>Application of physical metallurgy principles to nonequilibrium thermo-mechanical conditions associated with welding in structural alloys and focus on carbon steels. Includes welding metallurgy laboratories. Prereq: MatScEn 2251 and 3141, and enrollment as a WeldEng-BS or MatEng-BS major. Not open to students with credit for 4611.</td>
</tr>
<tr>
<td>4102</td>
<td>Welding Metallurgy II</td>
<td>U 4</td>
<td>Addresses the welding metallurgy and weldability principles associated with stainless steels, nickel-base, aluminum-base, and titanium-base alloys and other nonferrous alloys. Includes laboratories. Prereq: 4101, and enrollment as WeldEng-BS major; or permission of instructor. Not open to students with credit for 4612.</td>
</tr>
<tr>
<td>4112</td>
<td>Weldability</td>
<td>U 3</td>
<td>Teaches the basic concepts of weldability and focuses on failure mechanisms in welded construction. Failure phenomena that occur during fabrication, repair, and during service are discussed. Prereq: 4101, and WeldEng-BS major; or permission of instructor. Not open to students with credit for 714 or 715.</td>
</tr>
<tr>
<td>4115</td>
<td>Computational Modeling of Additive Manufacturing and Welding</td>
<td>U 3</td>
<td>Theory of temperature, stress, deformation and phase transformation for additive manufacturing and welding, as well as application of industry-standard simulation codes. Prereq: 4201, or permission of instructor.</td>
</tr>
<tr>
<td>4121</td>
<td>Computational Thermodynamics and Kinetics</td>
<td>U 2</td>
<td>Comprehensive background on computational thermodynamics and kinetics. Includes focus on CALPHAD (Calculation of Phase Diagram) methodology. Prereq: MatScEn 2251 and 3141 or equivalents; or Grad standing in MatScEn or WeldEng; or permission of instructor. Not open to students with credit for 7121. Cross-listed in MatScEn 5321.</td>
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<tr>
<td>Course Code</td>
<td>Course Title</td>
<td>Credits</td>
<td>Description</td>
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<tr>
<td>4999</td>
<td>Undergraduate Research</td>
<td>U</td>
<td>½ - 3</td>
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<tr>
<td></td>
<td>Supervised undergraduate research on topics in Welding Engineering (non-honors version).</td>
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<td></td>
<td>Prereq: Enrollment in WeldEng-BS major, and permission of instructor. Repeatable to a maximum of 6 cr hrs or 6 completions.</td>
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<tr>
<td>4999H</td>
<td>Undergraduate Honors Research in Welding Engineering</td>
<td>U</td>
<td>1 - 3</td>
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<td>Honor program students are offered the opportunity for supervised undergraduate research in Welding Engineering. Student presentation and thesis writing included.</td>
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<td></td>
<td>Prereq: Honors standing, enrollment as a WeldEng-BS major, and permission of instructor. Repeatable to a maximum of 8 cr hrs or 6 completions.</td>
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<tr>
<td>5193.01</td>
<td>Individual Studies in Welding Engineering</td>
<td>U G</td>
<td>0 - 6</td>
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<td></td>
<td>Investigations in areas of advanced non-thesis research. Library and/or research investigations under direction of instructor(s). Comprehensive report required.</td>
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<td></td>
<td>Prereq: Enrollment in MatSEng-BS or WeldEng-BS major, or Grad standing in Engr, or permission of instructor. This course is graded S/U.</td>
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<tr>
<td>5193.02</td>
<td>Individual Study in Welding Engineering</td>
<td>U G</td>
<td>½ - 6</td>
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<td>Investigations in areas of advanced non-thesis research. Library and/or research investigations under direction of instructor(s). Comprehensive report required.</td>
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<td>Prereq: Grad standing in Engr, Math, Physics, or Chem; or permission of instructor. Repeatable to a maximum of 12 cr hrs or 10 completions.</td>
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<tr>
<td>6193.01</td>
<td>Individual Studies in Welding Engineering</td>
<td>G</td>
<td>½ - 6</td>
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<tr>
<td></td>
<td>Investigations in areas of advanced non-thesis research. Library and/or research investigations under direction of instructor(s). Comprehensive report required.</td>
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<tr>
<td></td>
<td>Prereq: Grad standing in Engr, Math, Physics, or Chem; or permission of instructor. Repeatable to a maximum of 12 cr hrs or 10 completions.</td>
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<tr>
<td>6194</td>
<td>Group Studies in Welding Engineering</td>
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<td>1 - 4</td>
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<tr>
<td></td>
<td>Special topics in Welding Engineering. Topic, credit hours, and instructor will be announced in the preceding semester.</td>
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<tr>
<td>6999</td>
<td>Graduate Research in Welding Engineering</td>
<td>G</td>
<td>½ - 18</td>
</tr>
<tr>
<td></td>
<td>Research for thesis purposes only. Repeatable to a maximum of 45 cr hrs or 15 completions. This course is graded S/U.</td>
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<tr>
<td>7001</td>
<td>Physical Principles in Welding Processes I</td>
<td>G</td>
<td>3</td>
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<tr>
<td></td>
<td>Study of the application of physical principles in engineering of arc welding processes and equipment.</td>
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<td></td>
<td>Prereq: Grad standing, or permission of instructor. Not open to students with credit for 4001 (500) or 600.</td>
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<tr>
<td>7002</td>
<td>Physical Principles of Welding Processes II</td>
<td>G</td>
<td>3</td>
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<tr>
<td></td>
<td>Study of the application of physical principles in engineering of non-arc welding processes and equipment.</td>
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<td>Prereq: 7001 or 4001, and Grad standing; or permission of instructor. Not open to students with credit for 4002 (600) or 601.</td>
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<tr>
<td>7012</td>
<td>Resistance Welding Processes</td>
<td>G</td>
<td>3</td>
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<tr>
<td></td>
<td>Addresses the fundamentals, theory, and application of Resistance Welding processes, with emphasis on processes, equipment, materials, and quality control.</td>
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<td></td>
<td>Prereq: 7002 or 4002, and Grad standing; or permission of instructor. Not open to students with credit for 4012 (602) or 702.</td>
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<tr>
<td>7021</td>
<td>Solid-State Welding/Jointing</td>
<td>G</td>
<td>3</td>
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<tr>
<td></td>
<td>The welding and joining of materials in the solid state with emphasis on physical processes and metallurgical principles.</td>
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<td></td>
<td>Prereq: 7001, 7002, 7101, 7102, 4001, 4002, 4101, or 4102, and Grad standing; or permission of instructor. Not open to students with credit for 4021 (701).</td>
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<tr>
<td>7023</td>
<td>Brazing and Soldering</td>
<td>G</td>
<td>3</td>
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<tr>
<td></td>
<td>Brazing and soldering processes with emphasis on physical and metallurgical principles, materials, design and application considerations.</td>
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<td></td>
<td>Prereq: 7101 or 4101, and 7102 or 4102, and Grad standing; or permission of instructor. Not open to students with credit for 4023 (703).</td>
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<tr>
<td>7024</td>
<td>High Energy Density Welding Processes</td>
<td>G</td>
<td>3</td>
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<tr>
<td></td>
<td>Theory and practice of laser, electron beam, and other high energy density welding processes.</td>
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<tr>
<td></td>
<td>Prereq: Grad standing; or permission of instructor. Not open to students with credit for 4024.</td>
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<tr>
<td>7101</td>
<td>Welding Metallurgy I</td>
<td>G</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Application of physical metallurgy principles to nonequilibrium thermo-mechanical conditions associated with welding in structural alloys and focus on carbon steels.</td>
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<td></td>
<td>Prereq: Grad standing; or permission of instructor. Not open to students with credit for 4101 (610) or 611.</td>
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<tr>
<td>7102</td>
<td>Welding Metallurgy II</td>
<td>G</td>
<td>3</td>
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<tr>
<td></td>
<td>Addresses the welding metallurgy and weldability principles associated with stainless steels, and nickel-base, aluminum-base, and titanium-base alloys.</td>
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<td>Prereq: 7101 or 4101, and Grad standing; or permission of instructor. Not open to students with max credit for 4102 (612).</td>
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<tr>
<td>7112</td>
<td>Weldability</td>
<td>G</td>
<td>3</td>
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<tr>
<td></td>
<td>Teaches the basic concepts of weldability and focuses on failure mechanisms in welded construction. Failure phenomena that occur during fabrication, repair, and during service are discussed.</td>
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<td></td>
<td>Prereq: Grad standing, or permission of instructor. Not open to students with credit for 4112 (714) or 715.</td>
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<tr>
<td>7115</td>
<td>Computational Modeling of Additive Manufacturing and</td>
<td>G</td>
<td>3</td>
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<tr>
<td></td>
<td>Welding (Grad)</td>
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<tr>
<td></td>
<td>Graduate-level instruction on the theory of temperature, stress, deformation and phase transformation for additive manufacturing and welding, as well as application of industry-standard simulation codes.</td>
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<td></td>
<td>Prereq: Grad standing in Engineering, Mathematics, Physics, or Chemistry; or permission of instructor. Not open to students with credit for 4115.</td>
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<tr>
<td>7121</td>
<td>Computational Thermodynamics and Kinetics</td>
<td>G</td>
<td>3</td>
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<tr>
<td></td>
<td>Comprehensive background on computational thermodynamics and kinetics. Includes focus on CALPHAD (Calculation of Phase Diagram) methodology.</td>
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<td></td>
<td>Prereq: Math 2251 and 3151, or equiv, or Grad standing in Math or WeldEng, or permission of instructor. Not open to students with credit for 4121. Cross-listed in Math 5321.</td>
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</tr>
<tr>
<td>7123</td>
<td>Advanced Metallurgy for Brazing and Soldering</td>
<td>G</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Graduate level physical-chemical concepts of brazability and solderability of metals, ceramics, and glasses and focuses on wetting by liquid filler metals, interfacial reactions, phase compositions of joint metal, hetero-diffusion, liquid embrittlement, as well as strength and reliability of brazed and soldered joints manufactured in aerospace, electronic, optical, mining, and other industries.</td>
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<td></td>
<td>Prereq: 4023 or 7023, and Grad standing; or permission of instructor.</td>
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<tr>
<td>7193.01</td>
<td>Individual Studies in Welding Engineering</td>
<td>G</td>
<td>½ - 6</td>
</tr>
<tr>
<td></td>
<td>Non-thesis research investigations under the directions of instructors. Comprehensive report required. Repeatable to a maximum of 12 cr hrs or 12 completions. This course is graded S/U.</td>
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<tr>
<td>7193.02</td>
<td>Individual Studies in Welding Engineering</td>
<td>G</td>
<td>½ - 12</td>
</tr>
<tr>
<td></td>
<td>Non-thesis research investigations under the directions of instructors. Comprehensive report required. Repeatable to a maximum of 12 cr hrs or 12 completions.</td>
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<tr>
<td>7194</td>
<td>Group Studies in Welding Engineering</td>
<td></td>
<td>1 - 4</td>
</tr>
<tr>
<td></td>
<td>Special topics in welding engineering: topic, credit hours, and instructor will be announced in the previous semester.</td>
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<tr>
<td>7201</td>
<td>Engineering Analysis for Design and Simulation</td>
<td>G</td>
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<tr>
<td></td>
<td>Fundamentals of engineering analysis of heat flow, thermal and residual stresses, and fracture and fatigue with applications to design and simulation in welding and manufacturing.</td>
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<td></td>
<td>Prereq: Grad standing, or permission of instructor. Not open to students with credit for 4201 (620) or 621.</td>
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<tr>
<td>7202</td>
<td>Welding Design</td>
<td>G</td>
<td>3</td>
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<tr>
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<td>Fundamentals of design and application of codes and standards for welded structures.</td>
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<td>Prereq: Grad standing, or permission of instructor. Not open to students with credit for 4202 (641) or 621.</td>
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<tr>
<td>7240</td>
<td>Fitness-for-Service of Welded Structures</td>
<td>G</td>
<td>2</td>
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<tr>
<td></td>
<td>The interrelationship of design, fabrication, nondestructive evaluation, fracture mechanics, and reliability concepts in establishing the overall fitness-for-purpose of welded structures.</td>
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<td>Prereq: Grad standing, or permission of instructor. Not open to students with credit for 4240 (745).</td>
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<tr>
<td>7301</td>
<td>Nondestructive Evaluation</td>
<td>G</td>
<td>3</td>
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<tr>
<td></td>
<td>Main concepts of Nondestructive Evaluation of materials as apply to inspections of joints and structures; principles of conventional methods, their capabilities and limitations.</td>
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<td>Prereq: Grad standing, or permission of instructor. Not open to students with credit for 4301 (631).</td>
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<tr>
<td>7406</td>
<td>Welding of Plastics and Composites</td>
<td>G</td>
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<tr>
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<td>Theory and practice in welding of plastics and polymeric composites, including theory and analysis of welding processes, part and joint design, and process selection.</td>
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<td>Prereq: Grad standing, or permission of instructor. Not open to students with credit for 4406 (706).</td>
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<tr>
<td>7407</td>
<td>Adhesive Bonding and Mechanical Joining of Plastics</td>
<td>G</td>
<td>2</td>
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<td></td>
<td>Fundamentals of adhesive bonding science and technology and methods for mechanical joining of plastics including fasteners, snap-flats, press-flats, swaging, and staking.</td>
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<tr>
<td></td>
<td>Prereq: Grad standing, or permission of instructor. Not open to students with credit for 4407 (707).</td>
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</table>
7611 Welding Metallurgy Laboratory I
G 1
Fundamental understanding of microstructure evolution in alloys and steels during heat treatment, as well as welding through various characterization techniques. Prereq: Grad standing. Concur: 4101 or 7101; or permission of instructor. Not open to students with credit for 4611 (661).

7612 Welding Metallurgy Laboratory II
G 1
Offered in conjunction with 7102 - Welding Metallurgy II. The course demonstrates microstructure evolution and weldability principles in stainless steels and nonferrous alloys. Prereq or concur: 7102, and Grad standing; or permission of instructor. Not open to students with credit for 4612 (662).

7895 Graduate Seminar
G 1
Presentations and discussion by graduate students and involved outside speakers on thesis research and current problems in Welding Engineering. Prereq: Grad standing in WeldEng. Repeatable to a maximum of 20 cr hrs. This course is graded S/U.

8194 Group Studies in Welding Engineering
G 1 - 4
Special topics in Welding Engineering. Topic, credit hours, and instructor will be announced in the preceding semester. Prereq: Permission of instructor. Repeatable to a maximum of 12 cr hrs or 8 completions.

8999 Graduate Research in Welding Engineering
G ½ - 18
Research for dissertation purposes only. Repeatable to a maximum of 60 cr hrs or 20 completions. This course is graded S/U.
### Historical Information
- Established by Legislature: 1870
- First classes taught: 1873
- Received present name: 1878
- First graduating class: 1878
- Degrees granted (through SP 2020): 799,256

### Academic Structure (Autumn 2020)
- Colleges: 15
- Undergraduate majors: > 250*
- Master’s degree programs: 162
- Doctoral degree programs: 105
- Professional degree programs: 9
- Courses (estimated): 12,000

* Number of majors varies depending on specialty, track and other factors.

### Buildings (Autumn 2020)
- Total: 1,331
  - Columbus campus (Franklin County): 590
  - Lima, Mansfield, Marion, Newark campuses: 82
  - Wooster (OARD & ATI): 290
  - Satellite—Columbus Campus (Non-Franklin County): 369

### Acreage (Autumn 2020)
- Total: 16,095
  - Columbus campus: 1,674
  - Lima, Mansfield, Marion, Newark campuses: 1,482
  - Wooster (OARD, ATI, and all other OARD sites): 8,652
  - Molly Caren Agricultural Center: 2,092
  - Don Scott Airport: 1,338
  - Golf Courses: 485
  - Miscellaneous—Satellite: 371

### Enrollment (Autumn 2020)

<table>
<thead>
<tr>
<th></th>
<th>Columbus Campus</th>
<th>Total University</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>61,369</td>
<td>67,957</td>
</tr>
<tr>
<td>By Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>29,768</td>
<td>32,857</td>
</tr>
<tr>
<td>Women</td>
<td>31,601</td>
<td>35,100</td>
</tr>
<tr>
<td>By Level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undergraduates</td>
<td>46,984</td>
<td>53,557</td>
</tr>
<tr>
<td>Graduate students</td>
<td>11,095</td>
<td>11,110</td>
</tr>
<tr>
<td>Professional students</td>
<td>3,290</td>
<td>3,290</td>
</tr>
<tr>
<td>By Residency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ohioans</td>
<td>43,069</td>
<td>49,596</td>
</tr>
<tr>
<td>Non-Ohioans</td>
<td>18,300</td>
<td>18,361</td>
</tr>
<tr>
<td>Foreign students</td>
<td>5,566</td>
<td>5,580</td>
</tr>
<tr>
<td>Students with Disabilities*</td>
<td>4,174</td>
<td>1,085</td>
</tr>
<tr>
<td>Veterans &amp; Service Members</td>
<td>1,085</td>
<td></td>
</tr>
</tbody>
</table>

* Self-identified students whose disability has been documented based on OSU standards.

### Tuition and Fees (2020-2021)

<table>
<thead>
<tr>
<th></th>
<th>Semester</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ohio undergraduate (Columbus, new)*</td>
<td>$5,759</td>
<td>$11,158</td>
</tr>
<tr>
<td>Ohio undergraduate (Regional, new)**</td>
<td>$4,118</td>
<td>$8,236</td>
</tr>
<tr>
<td>Nonresident undergraduate (Cols., new)*</td>
<td>$16,751</td>
<td>$33,502</td>
</tr>
<tr>
<td>Ohio graduate (Columbus, new)*</td>
<td>$6,212</td>
<td>$12,425</td>
</tr>
<tr>
<td>Nonresident graduate (Columbus, new)*</td>
<td>$18,570</td>
<td>$37,141</td>
</tr>
<tr>
<td>Typical annual cost, all fees***</td>
<td></td>
<td>$28,664</td>
</tr>
</tbody>
</table>

*Includes COTA, Student Activity, Recreational, and Student Union Facility fees.
**Fees exclude program and technology fees.
***Typical fees for a new first year freshman on Columbus campus.
Under the Ohio State Tuition Guarantee, rates for new first-year undergraduate students entering in 2020-2021 will be frozen for four years.
Statistical Summary 2020-2021

Budget, Fiscal Year 2021 (as approved by Trustees)

<table>
<thead>
<tr>
<th>Total revenues</th>
<th>$7.6 billion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuition and Fees</td>
<td>$1.1 billion</td>
</tr>
<tr>
<td>State Support</td>
<td>$464 million</td>
</tr>
<tr>
<td>Auxiliary</td>
<td>$205 million</td>
</tr>
<tr>
<td>Health System</td>
<td>$4.0 billion</td>
</tr>
<tr>
<td>Other</td>
<td>$1.8 billion</td>
</tr>
</tbody>
</table>

Total expenditures $7.2 billion

| Salaries             | $1.5 billion |
| Benefits             | $417 million |
| Financial Aid        | $431 million |
| Health System        | $3.4 billion |
| Other                | $1.4 billion |

Financial Information (Fiscal Year: July 1-June 30)
(Figures are rounded and may not sum to total)

Research Highlights

Research Expenditures (2019-2020) $968.2 million

Sponsored Programs $592.0 million
Research Institute at Nationwide Children’s Hospital $87.4 million
Transportation Research Center $35.4 million
Other Research Programs (including OARDC) $101.8 million
Institution (Cost sharing and support) $151.6 million

Rank among U.S. public research universities based on research expenditures (NSF ‘19) 15th
Rank among all U.S. universities based on industry-sponsored research (NSF ‘19) 4th

Employees (Autumn 2020)

<table>
<thead>
<tr>
<th>Total</th>
<th>37,339.90</th>
<th>45,407</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular Tenure Track Faculty</td>
<td>2,814.55</td>
<td>2,827</td>
</tr>
<tr>
<td>Regular Clinical Faculty</td>
<td>1,937.75</td>
<td>2,009</td>
</tr>
<tr>
<td>Regular Research Faculty</td>
<td>100.99</td>
<td>105</td>
</tr>
<tr>
<td>Associated Faculty</td>
<td>2,108.42</td>
<td>2,655</td>
</tr>
<tr>
<td>Unclassified Staff</td>
<td>21,940.13</td>
<td>23,134</td>
</tr>
<tr>
<td>Civil Service Staff</td>
<td>4,987.70</td>
<td>5,110</td>
</tr>
<tr>
<td>Student Employees</td>
<td>3,450.36</td>
<td>9,567</td>
</tr>
</tbody>
</table>

Annual Payroll (2019-2020)

For all employees $3.080 billion

Endowment (Total University and Foundation)

Market value, as of June 30, 2020 $5.287 billion

Fund Raising (2019-2020)

Donors 237,338
Total new activity $509.9 million

Administration

Kristina M. Johnson President
Bruce A. McPheron Executive Vice President and Provost

Trustees

<table>
<thead>
<tr>
<th></th>
<th>Term Ending</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gary R. Heminger, Chair</td>
<td>2027</td>
</tr>
<tr>
<td>Abigail S. Wexner, Vice Chair</td>
<td>2023</td>
</tr>
<tr>
<td>Cheryl L. Krueger</td>
<td>2021</td>
</tr>
<tr>
<td>Michael Kiggin</td>
<td>2021</td>
</tr>
<tr>
<td>Brent R. Porteus</td>
<td>2022</td>
</tr>
<tr>
<td>Erin P. Hoeftinger</td>
<td>2022</td>
</tr>
<tr>
<td>Alex R. Fischer</td>
<td>2023</td>
</tr>
<tr>
<td>Hiroyuki Fujita</td>
<td>2024</td>
</tr>
<tr>
<td>Alan A. Stockmeister</td>
<td>2025</td>
</tr>
<tr>
<td>John W. Zeiger</td>
<td>2026</td>
</tr>
<tr>
<td>Elizabeth P. Kessler</td>
<td>2027</td>
</tr>
<tr>
<td>Lewis Von Thaer</td>
<td>2028</td>
</tr>
<tr>
<td>Jeff M.S. Kaplan</td>
<td>2028</td>
</tr>
<tr>
<td>Elizabeth A. Harsh</td>
<td>2029</td>
</tr>
<tr>
<td>Reginald A. Wilkinson</td>
<td>2029</td>
</tr>
<tr>
<td>Anand Shah, Undergraduate Member</td>
<td>2021</td>
</tr>
<tr>
<td>Carly G. Sobol, Graduate Member</td>
<td>2021</td>
</tr>
<tr>
<td>James D. Klingbeil, Charter Trustee</td>
<td>2021</td>
</tr>
</tbody>
</table>

Abbreviations:
ATI = Agricultural Technical Institute; FTE = Full-time Equivalent; OARDC = Ohio Agricultural Research and Development Center

Provided by: Office of Institutional Research
With one of the largest concentrations of electron and ion beam analytical microscopy instruments in any North American institution, CEMAS brings together multidisciplinary expertise to drive synergy, amplify characterization capabilities, and challenge what is possible in analytical electron microscopy.

Our point of difference is our world-class multidisciplinary approach that enables academic and business partners to “see” more than ever before. We are challenging the current characterization limitations in medicine, environmental science, energy materials and beyond.

Our full-service facility – from extensive sample preparation laboratories to image-processing tools and support – allows researchers to carry out their entire microscopy and analysis program at CEMAS. Located in a purpose built facility on The Ohio State University’s West Campus, every instrument in the facility meets or exceeds manufacturer performance specifications. A support team of technical, research, administrative and academic staff based at CEMAS provides comprehensive support to all users through a variety of mechanisms from contract research to collaborative projects.

CEMAS KEY FEATURES

- World class multi scale imaging facility: optical scale to atomic resolution
- A unique, custom-designed environment where every instrument meets or exceeds manufacturer performance specifications
- Highly skilled support staff available to all users
- The electron microscopy collaboratory: a digital theater providing remote access to allow students and lecturers to seamlessly operate electron and ion microscopes
- Delivering solutions to medicine, advanced manufacturing, environmental science, energy harvesting and storage, and healthcare
- Comprehensive computer facilities for processing, simulation, and visualization of 2D and 3D datasets
- Extensive sample preparation laboratories for engineering, physical and biological sciences
World-class microscopy education in the theory of electron microscopy and all aspects of its use and operation is also available at CEMAS, both in-house and remotely, through our digital theater. Students have live access to CEMAS instruments in real time within a state-of-the-art classroom environment to meet every microscopy training need.

Video wall technology provides multiple display screens and projectors, allowing simultaneous display of microscope controls, microscope outputs and lecture slides. Students and lecturers can interact with and operate electron and ion microscopes from within the digital theater in a live, seamless manner – as if one were sitting in front of the instrument. Control of the microscope can be transferred to members of the audience using wired and wireless connectivity.

The microscopes can also be shared with students and researchers at geographically distant locations. Remote operation capabilities connect directly to the 100 Gb/s Ohio OARnet network, providing a unique opportunity for remote teaching and research to partners across the state of Ohio. CEMAS is pioneering the practical application of this technology for research and training of the next generation of electron microscopy specialists, providing an environment to facilitate world-class collaborative research, and maximizing productivity while minimizing economic and environmental impact. This remote electron microscopy collaborative system has been installed at the University of Dayton, The Ohio State University’s Wooster campus and the Air Force Research Laboratory at Wright-Patterson Air Force Base (Dayton), with additional locations planned for the near future.

INSTRUMENTS

- Thermo Scientific Image Corrected Titan³ G2 60-300 S/TEM
- Thermo Scientific Probe Corrected Titan³ 80-300 S/TEM
- Thermo Scientific Glacios
- Thermo Scientific Tecnai F20 S/TEM
- Thermo Scientific Tecnai G2 30 TWIN
- Thermo Scientific Helios NanoLab 600 DualBeam (FIB/SEM)
- Thermo Scientific Nova NanoLab 600 DualBeam (FIB/SEM)
- Thermo Scientific Quattro S eSEM
- Thermo Scientific Apreo LoVac Analytical
- Thermo Scientific Apreo LoVac High Resolution
- Thermo Scientific Quanta 200 eSEM
- Thermo Scientific HeliScan microCT
- Rigaku SmartLab
- Rigaku MiniFlex 600

CEMAS is a core research facility at The Ohio State University established through funding from the university’s College of Engineering, Office of Research, Office of Academic Affairs, Department of Materials Science and Engineering, and Institute for Materials Research and the Ohio Development Services Agency and Ohio Third Frontier Program.
Mission

To establish a collaborative research environment between universities and industrial partners which promotes the development and application of fundamental knowledge in the areas of materials joining and additive manufacturing, and provides a platform for the education of the next generation of scientist and engineers.

Background

Industry faces the dual challenge of introducing new materials into products of the future and assuring that current materials meet performance requirements. Both of these challenges require a better fundamental knowledge of materials joining and additive manufacturing. This requires a multidisciplinary approach that occurs at the intersection of the joining and manufacturing processes and the materials' reaction to its environment. Aspects of manufacturing and joining processes, materials science, and structural design must be considered in this multi-disciplinary approach.

Ma2JIC continues to have a significant impact on innovation, competitiveness, and the sustainability of fabrication, welding, and additive manufacturing. Industry members of Ma2JIC have realized increased productivity, reduced overall costs, and higher quality components and structures.

“Center membership allows us to keep a pulse on industry issues and to leverage our R&D with other interested members to solve these issues.”
- Industry Member

Ma2JIC Focus Areas

Materials Weldability: Successful adoption of conventional and advanced materials requires the ability to successfully fabricate and join them. A range of cracking and failure modes can occur when joining materials due to fundamental knowledge gaps on weldability. Ma2JIC research teams examine the material weldability to determine effective methods and approaches to successfully join these materials and quantitatively access its weldability.

Additive Manufacturing: Additive manufacturing (AM) is now being used to address unique challenges, reduce costs, and manufacture parts for critical service. Laser, electron beam, or arc welding processes (and others) are integral to many AM processes. Based on the fundamental understanding of advanced materials, welding processes, process modeling, and industrial applications, the researchers within Ma2JIC are ideally positioned to address the challenges associated with the use of AM technology for product development.

Modeling Innovation: Process, microstructural, and structural modeling specific to joining and additive manufacturing is evolving to the point where models can be applied to a broad range of industrial applications. The use of modeling and/or simulation is emphasized in the majority of Ma2JIC projects. Members have experienced the benefits of modeling and simulation to increase process and materials understanding, expedite development, improve performance, and extend the lifetime of products.

Materials Performance: A clear understanding of material processing - microstructure - properties - performance relationship is essential for the development and use of advanced materials. Expertise and experience within Ma2JIC is applied to clearly understand the relationships above and successfully implement solutions so that increasingly demanding design requirements can consistently be met.
Manufacturing and Joining Processes Development:
Continuous process innovation is vital to high productivity, achieving high quality, and improved performance, while supporting our advanced manufacturing global competitiveness. As industry needs, materials, and applications evolve; new and improved manufacturing and joining technologies are required to meet new challenges. Ma2JIC considers a full-lifecycle approach when developing and implementing process innovations.

Why Become a Ma2JIC Member?

- Significant leveraging of your research money. For a $50k yearly membership fee, you get access to over 16 million dollars of research.
- Interaction with leading universities involved in manufacturing and materials joining research
- Access to highly trained students with expertise in materials joining. Many of our students are hired by our members because they know other welding engineering students don't have our level of expertise.
- Ability to structure projects that have direct impact on current and future joining issues
- Reduced project overhead (10% indirect costs) allows most of membership funds to be devoted to student support and research.
- Access to the center's faculty. Our center directors have an average of over 33 years of welding engineering experience.

Center Director
Antonio J. Ramirez
The Ohio State University
ramirezlondono.1@osu.edu

Site Directors
John DuPont
Lehigh University
jnd1@lehigh.edu

Stephen Liu
Colorado School of Mines
sliu@mines.edu

Claudia Rawn
University of Tennessee Knoxville
crawn@utk.edu

Center Manager
Brooke Felts
(614) 292-1182
felts.13@osu.edu

Website
ma2jic.osu.edu

E-mail
eng-mse-ma2jic@osu.edu
Housing information

On campus housing

Neil Avenue Building
Rates: These rooms are rented at the base rate of $830 paid per month on a one year lease.
Amenities: This building is located on South Campus (MSE is on the north side of campus) and features personal kitchen facilities, its own grocery and convenient store, and laundry facilities. Meal plans are optional.

Off campus housing

1-2 Bedroom apartments
Range of pricing near MSE: $400-$1400/per person

3-4 Bedroom apartments
Range of pricing near MSE: $500-$1000/per person

Columbus, Ohio

About: Columbus has a population of nearly 770,000 residents within the city; roughly 1.7 million residents in the Greater Columbus region. The average age of a resident here is 31 years old, with a median family income of approximately $40,500+. Columbus residents benefit from a stable local economy, supported by diverse economic streams. Its business-friendly environment has attracted significant corporations to the area such as five Fortune 500 company headquarters, and one Fortune 100 company headquarters. The entrepreneurial spirit is alive and well in Columbus, and some of the flags that were brought to life here include The Limited, the Scotts Company, and Wendy's.

Perhaps the local economy is bolstered by its citizens’ easy access to continuing education. The city of Columbus boasts seventeen institutions of higher learning, including Ohio Wesleyan University and Ohio State University. There are currently over 100,000 college students enrolled at various colleges and universities here, making it one of the largest college towns in America.

Columbus has some great entertainment, artistic and recreational opportunities for residents to take advantage of in their free time. If you prefer spectator sports, Columbus offers minor league baseball, major league soccer, NHL Blue Jackets, and Ohio State Buckeyes Football. And if sports aren't your thing, Columbus has its own ballet company, symphony, opera, and arts community.

Sources: city-data.com, columbusregion.com, wikipedia.com, factfinder.census.gov

Learn more about Columbus at experiencecolumbus.com
Columbus

The United States’ 15th-largest and 15th-fastest-growing city has been called the No. 1 opportunity city by Forbes. This must-visit destination (thanks, Expedia) has so many exciting projects underway that there’s never been a better time to meet in the Arch City.

Greater Columbus Convention Center
1.8-million-square-foot center to be highlighted by 373,000 square feet of contiguous exhibit space

#6
SmartAsset named Columbus the #6 best city for conferences in 2016.

More than 150 works of local art displayed on the interior and exterior of the building and parking garages

100+ restaurants within walking distance of the center, including 25 vendors under the roof of the North Market

Time named Columbus one of the six best big cities in the country and the best big city in the Midwest.

HOTELS
15 downtown hotels
4,000 hotel rooms downtown
2,100 hotel rooms connected/adjacent to GCCC
298 hotels citywide
28,035 hotel rooms citywide

Columbus-based Jeni’s Splendid Ice Creams is one of the best in the country, according to Food & Wine.

One of the 25 best tourism websites in the world in 2016, according to Skift

AirConnect picks up from John Glenn Columbus International Airport to the convention center and downtown hotels every 30 minutes.

Up to 150 daily departures to 33 destinations nonstop

a one-day drive or one-hour flight from nearly half of the U.S. population

Metro Population: 2.02 million

15
downtown
hotels

2,02
million
population

100+
restaurants

1.8
million
square
foot
center

373,000
square
feet

373,000
square
feet
contiguous
exhibit
space

373,000
square
feet

25
vendors
under
roof

25
vendors
under
roof

#6

28,035
hotel
rooms

28,035
hotel
rooms

4,000
hotel
rooms

4,000
hotel
rooms

28,035
hotel
rooms

2,02
million
population

2,02
million
population

2,02
million
population

2,02
million
population

2,02
million
population
17 Arches along High Street in the Short North have earned Columbus the moniker Arch City.

COSI, the Center of Science and Industry has entered into a first-of-its-kind partnership with the American Museum of Natural History for a new dinosaur exhibit.

61 college and university campuses with a total enrollment of more than 136,000 students

3rd-highest concentration of fashion designers in the country behind New York and Los Angeles

Winner of the $40-MILLION U.S. Department of Transportation Smart City Challenge grant

28 breweries make up the Columbus Ale Trail.

Country’s largest free outdoor climbing wall, accessible from paths along the river

17 coffee shops make up the Columbus Coffee Trail.

CBUS Free downtown circulator runs every 10 to 15 minutes from the Short North Arts District in the north to the Brewery District/German Village in the south, with many stops at popular downtown locations along the way.

253 acres of downtown greenspace, 175 acres on the Scioto Mile along the downtown riverfront

The National Veterans Memorial & Museum opens in mid-2018 on downtown’s Scioto Peninsula — the only place where the stories of U.S. veterans, their families, and the fallen, across all branches of service and all eras of conflict, will be told together.