### 2020-2021 Materials Engineering Master of Science

### ****Master of Science in Materials Engineering:****

**Prerequisites to Degree Program:** Applicants to the program must satisfy the requirements of the Graduate School as described in this catalog and have the approval of the Graduate Studies Committee of the Materials Science & Engineering program (GSCSMSEN) .

Candidates have completed an ABET-accredited or equivalent Bachelor of Science degree in engineering and  candidates’ academic backgrounds will be evaluated by the GSCSMSEN for suitability to the graduate program. To be admitted to graduate study in Materials Science and Engineering (MSEN) without deficiency, candidates are required to have completed a math course sequence through differential equations and an introduction to quantum mechanics through courses such as PHYS 3603 Introduction to Modern Physics, PHYS 3613 Modern Physics, or CHEM 3504 Physical Chemistry I. Other undergraduate deficiencies may be identified during the evaluation process, and degree completion will be contingent on successful completion of these identified deficiencies.

Prospective students from foreign countries in which English is not the native language must submit nationally recognized standardized testing results on written English proficiency for consideration by the Graduate School during the admission process. Students may be given conditional admittance pending demonstration of English language skills in appropriate courses at the University of Arkansas. Students wishing to apply for graduate assistantships that require direct contact with students in a teaching or tutorial role must meet the Graduate School’s English Language proficiency test requirements for such GA positions.

**Requirements for the Master of Science in Materials Engineering Degree:** Students choosing this degree program will be assigned an initial adviser upon acceptance to the program. Students will work with the MSEN Program Director to define their M.S. path to best support their career goals after graduation, with three curricula paths available to Materials Engineering students:

* Academic path: Students who plan to complete an academic campus-based research thesis will take this path, although the research topic may include funding and collaboration with outside technical organizations. Students who complete all requirements for M.S. graduation, including an independent research project and thesis acceptable to their thesis committee, will be eligible without GSCSMSEN review for admission to the MSEN Ph.D. program.
* Professional path: Students who plan to enter the technical marketplace after M.S. completion will find this path most beneficial as it requires independent graduate-level research in collaboration with an external technical organization. The research may be in the form of a traditional M.S. six-hour research topic and thesis, or may instead be in the form of two three-hour independent research efforts resulting in written reports with the clarity, style, analysis, and conclusions expected of a journal paper submission. Both the thesis and the written reports will be orally defended before the appropriate student committee. Students in this path will also be required to complete at least one internship of at least six weeks duration to experience a non-academic technical environment. Students completing this path may be considered by the GSCSMSEN for admission to the MSEN Ph.D. program based on the strength of their academic course grades, their independent research depth, and the quality of the written research document.
* Non-thesis path: Students who are funded by personal resources or by graduate assistantships not associated with research or educational grants may complete an M.S. degree with additional course work in place of independent research. While there may be specific narrow career options where this is an appropriate path, the MSEN program strongly recommends the Professional or Academic paths as providing a much better overall career preparation for working in a technical position. Students completing this path cannot be accepted into the MSEN Ph.D. program.

Students will form either a thesis committee or an advisory committee after they have chosen their M.S. path, defined any independent research areas, and have been accepted into a research group if appropriate. A thesis committee will be made up of at least three faculty members, with at least one faculty member each from the Fulbright College of Arts and Sciences and the College of Engineering (the student’s research professor will chair the thesis committee). The advisory committee will include at least one GSCSMSEN member, the supervising faculty member for a research experience, and one additional faculty member. If the student is in the Professional path, then either committee must also include at least one technical professional from the partner external organization as an adjunct faculty member or an ex officio committee member.

Students in this degree program can choose an Academic path, a Professional path, or a Non-thesis path. The course hours to meet the minimum requirements for each paths are as follows:

|  |
| --- |
| **Subject Area** | **Academic Path/Hours** | **Professional Path/Hours** | **Non-Thesis Path/Hours** |
| MEEG 591V Special Topics (Introduction to Manufacturing) (Core) | 3 | 3 | 3 |
| MSEN 5322 Materials Characterization (Core) | 2 | 2 | 2 |
| MSEN 5313 Fundamentals of Materials Science (Core) | 3 | 3 | 3 |
| MSEN 5383 Research Commercialization and Product Development (Core) | 3 | 3 | 3 |
| MSEN 5811 / MSEN 5911 / MSEN 6811 / MSEN 6911 Operations Management Seminar Series (Core) | 4 | 4 | 4 |
| MSEN 6323 Materials Engineering Design (Core) | 3 | 3 | 3 |
| Technical Electives from Concentration List | 9 | 9 | 9 |
| MSEN 600V Research Thesis | 6 | (Option) 6 | 0 |
| MSEN 5513 Applied Research in External Technical Organizations | Not Available | (Or Option) 3 + 3 | Not Available |
| MSEN 5523 Applied On Campus Collaborative Research with External Technical Organizations | Not Available | (Or Option) 3 + 3 | Not Available |
| MSEN 555V Internship in External Technical Organization or GNEG 5811 Alternating Cooperative Education | Optional (hours do not apply to degree requirement) | >/= 1 | Optional (hours do not apply to degree requirement) |
| MSEN 5821 Ethics for Scientists and Engineers | 1 (Applied in Ph.D. curriculum) | 1 | 1 |
| Additional Technical Elective | 0 | 0 | >/=2 |
| MSEN 5253 Emerging Technologies in Industry | Recommended in PhD studies | Recommended in PhD studies | 3 |
| MSEN 5393 Product Development Process | N/A | N/A | 3 |

If a University of Arkansas undergraduate student is pursuing a Bachelor of Science degree in a department that has implemented an accelerated B.S./M.S. program (typically allowing six hours of graduate-level course work to be shared between the two degrees), the student may implement the same acceleration for a B.S. departmental degree/M.S. Materials Engineering degree set. Both the undergraduate department and the MSEN program Director must approve the shared courses prior to enrollment.

As part of each student’s curriculum, nine hours of coursework must be taken through one of the following concentrations.  Courses not listed in the concentration list, but clearly pertaining to the concentration area, may be substituted with the approval of the student's research adviser and the MSEN program Director. Students who have acquired the knowledge contained in any of the required courses through prior education may petition the MSEN program Director for permission to substitute other classes for these required courses.

Additional core courses to develop operations management skills also have been defined for MSEN students. During year one of their graduate studies at the University of Arkansas, students are required to take MSEN 5811 1st year Operations Seminar - Infrastructure Management and MSEN 5911 1st Year Operations Seminar - Personnel Management in the fall and spring semesters and MSEN 5821 Ethics for Scientists and Engineers  in their first summer. During year two, students are required to take MSEN 6811 2nd Year Operations Seminar – Management and Leadership and MSEN 6911 2nd Year Operations Seminar – Advanced Management and Leadership in the fall and spring semesters, respectively.  Students who begin their graduate studies at the University of Arkansas during the spring semester will be required to take MSEN 5811 in the fall semester following their completion of MSEN 6911 or to take MSEN 5811 concurrently with MSEN 6811.

Students are required to attend monthly MSEN Research Communication Seminars during the first three semesters of their M.S. degree program, and will enroll in MSEN 5611 Research Communication Seminar of MS Students in their third semester.  Students working more than 20 hours per week in a non-local technology-based professional position approved by the MSEN Director will not be required to be enrolled in this class or attend the monthly seminars as a condition for graduation.

Research thesis hours will be chosen from the student’s research adviser's section (MSEN 600V) and will require a written thesis successfully defended in a comprehensive oral exam given by the thesis committee.

A research thesis is required for Academic path students, and is optional for Professional path students. Professional path thesis research must include direct collaboration with an external technical organization.

A student in the Professional path may substitute two Applied Research efforts for a thesis under MSEN 5513 (External location) or MSEN 5523 (Internal on-campus location), provided each semester’s research is of graduate-level quality and is reported at the end of the semester through a written paper and in an oral presentation to the advisory committee (note that the written paper must match the clarity, style, analysis, and conclusions expected of a journal paper submission). Regardless of where the research is performed, it must include direct collaboration with an external technical organization.

If a student is taking either a special problems independent study course (such as MSEN 588V) or a special topics course (such as MSEN 587V) to meet partial requirements for their M.S. degree, the instructor must supply the MSEN program office with a syllabus of that class to be included in their program records.  The syllabus must include at least the course title, semester, instructor name, a list of specific course objectives, sources of content knowledge, and method by which the student's mastery of the learning objectives is demonstrated.

Each student is required to enroll in at least one hour of course work each fall and spring semester until the M.S. degree is issued. If all required course work has been completed, the student may enroll in one hour of master’s thesis, or in one hour of a special problems course for credit only.

Students should also be aware of Graduate School requirements with regard to master's degrees.

### ****Master of Science in Materials Science:****

**Prerequisites to Degree Program:** Applicants to the program must satisfy the requirements of the Graduate School as described in this catalog and have the approval of the Graduate Studies Committee of the Materials Science and Engineering program (GSCSMSEN) .

Candidates typically have completed a Bachelor of Science degree in the physical or natural sciences and  candidates’ academic backgrounds will be evaluated by the GSCSMSEN for suitability to the graduate program. To be admitted to graduate study in Materials Science and Engineering (MSEN) without deficiency, candidates are required to have completed a math course sequence through differential equations and an introduction to quantum mechanics through courses such as PHYS 3603 Introduction to Modern Physics, PHYS 3613 Modern Physics, or CHEM 3504 Physical Chemistry I. Other undergraduate deficiencies may be identified during the evaluation process, and degree completion will be contingent on successful completion of these identified deficiencies.

Prospective students from foreign countries in which English is not the native language must submit nationally recognized standardized testing results on written English proficiency for consideration by the Graduate School during the admission process. Students may be given conditional admittance pending demonstration of English language skills in appropriate courses at the University of Arkansas. Students wishing to apply for graduate assistantships that require direct contact with students in a teaching or tutorial role must meet the Graduate School’s English Language proficiency test requirements for such GA positions.

**Requirements for the Master of Science in Materials Science Degree:** Students choosing this degree program will be assigned an initial adviser upon acceptance to the program. Students will work with the MSEN Program Director to define their M.S. path to best support their career goals after graduation, with three curricula paths available to Materials Science students:

* Academic path: Students who plan to complete an academic campus-based research thesis will take this path, although the research topic may include funding and collaboration with outside technical organizations. Students who complete all requirements for M.S. graduation, including an independent research project and thesis acceptable to their thesis committee, will be eligible without GSCSMSEN review for admission to the MSEN Ph.D. program.
* Professional path: Students who plan to enter the technical marketplace after M.S. completion will find this path most beneficial as it requires independent graduate-level research in collaboration with an external technical organization. The research may be in the form of a traditional M.S. six-hour research topic and thesis, or may instead be in the form of two three-hour independent research efforts resulting in written reports with the clarity, style, analysis, and conclusions expected of a journal paper submission. Both the thesis and the written reports will be orally defended before the appropriate student committee. Students in this path will also be required to complete at least one internship of at least six weeks duration to experience a non-academic technical environment. Students completing this path may be considered by the GSCSMSEN for admission to the MSEN Ph.D. program based on the strength of their academic course grades, their independent research depth, and the quality of the written research document.
* Non-thesis path: Students who are funded by personal resources or by graduate assistantships not associated with research or educational grants may complete an M.S. degree with additional course work in place of independent research. While there may be specific narrow career options where this is an appropriate path, the MSEN program strongly recommends the Professional or Academic paths as providing a much better overall career preparation for working in a technical position. Students completing this path cannot be accepted into the MSEN Ph.D. program.

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| **Subject Area** | **Academic Path/Hours** | **Professional Path/Hours** | **Non-Thesis Path/Hours** |
| --- | --- | --- | --- |
| MEEG 5343 Computational Materials Science | 3 | 3 | 3 |
| MEEG 591V Special Topics (Introduction to Manufacturing) (Core) | 3 | 3 | 3 |
| MSEN 5312 Materials Characterization (Core) | 2 | 2 | 2 |
| MSEN 5313 Fundamentals of Materials Science (Core) | 3 | 3 | 3 |
| MSEN 5383 Research Commercialization and Product Development | 3 | 3 | 3 |
| MSEN 5811 / MSEN 5911 / MSEN 6811 / MSEN 6911 Operations Management Seminar Series (Core) | 4 | 4 | 4 |
| Technical Electives from Concentration List | 9 | 9 | 9 |
| MSEN 600V Research Thesis | 6 | (Option) 6 | 0 |
| MSEN 5513 Applied External Research | Not Available | (Or Option) 3 + 3 | Not Available |
| MSEN 5323 Applied Internal Research | Not Available | (Or Option) 3 + 3 | Not Available |
| MSEN 555V Internship in External Technical Organization or GNEG 5811 Alternating Cooperative Education | Optional (hours do not apply to degree requirement) | >/= 1 | Optional (hours do not apply to degree requirement) |
| MSEN 5821 Ethics for Scientists and Engineers | Applied in Ph.D. Curriculum | 1 | 1 |
| Additional Technical Elective | 0 | 0 | >/=2 |
| MSEN 5253 Emerging Technologies in Industry | Recommended in PhD studies | Recommended in PhD studies | 3 |
| MSEN 5393 Product Development Process | Not Available | Not Available | 3 |

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If a student is taking either a special problems independent study course (such as MSEN 588V) or a special topics course (such as MSEN 587V) to meet partial requirements for their M.S. degree, the instructor must supply the MSEN program office with a syllabus of that class to be included in their program records.  The syllabus must include at least the course title, semester, instructor name, a list of specific course objectives, sources of content knowledge, and method by which the student's mastery of the learning objectives is demonstrated.

Each student is required to enroll in at least one hour of course work each fall and spring semester until the M.S. degree is issued. If all required course work has been completed, the student may enroll in one hour of master’s thesis, or in one hour of a special problems course for credit only.

Students should also be aware of Graduate School requirements with regard to master's degrees.

## Concentration in Biological Materials & Devices

Course List

Choose nine hours of the following: 9

BENG 4123 Biosensors & Bioinstrumentation

BENG 5103 Advanced Instrumentation in Biological Engineering

BENG 5743 Biotechnology Engineering

BMEG 5213 Tissue Mechanics

BMEG 5313 Advanced Biomaterials and Biocompatibility

ELEG 4253 Nanotechnology in Engineering & Medicine

ELEG 5773 Electronic Response of Biological Tissues

MEEG 5253 Bio-Mems

MEEG 5343 Computational Material Science

MSEN 6323 Materials Engineering Design Course

PHYS 5613 Introduction to Biophysics and Biophysical Techniques

## Concentration in Energy Materials & Devices

Course List

Choose nine hours from the following: 9

CHEM 5283 Energy Conversion and Storage

ELEG 5223 Design and Fabrication of Solar Cells

MEEG 5343 Computational Material Science

MSEN 5713 Advanced Nanomaterials Chemistry

MSEN 5733L Fabrication at the Nanoscale

MSEN 6323 Materials Engineering Design

## Concentration in Mechanical & Structural Materials

Course List

Choose nine hours of the following: 9

MEEG 5033 Advanced Mechanics of Materials I

MEEG 5123 Finite Elements Methods II

MEEG 5163 Advanced Product Design

MEEG 5303 Physical Metallurgy

MEEG 5343 Computational Material Science

MSEN 6323 Materials Engineering Design

PHYS 5713 Condensed Matter Physics I

PHYS 6713 Condensed Matter Physics II

## Concentration in Microelectronic-Photonic Materials & Devices

Course List

ELEG 5203 Semiconductor Devices 3

Choose six hours from the following: 6

ELEG 5213 Integrated Circuit Fabrication Technology

ELEG 5223 Design and Fabrication of Solar Cells

ELEG 5243L Microelectronic Fabrication Techniques and Procedures

ELEG 5273 Electronic Packaging

ELEG 5293L Integrated Circuits Fabrication Laboratory

ELEG 5313 Power Semiconductor Devices

ELEG 5323 Semiconductor Nanostructures I

ELEG 5333 Semiconductor Nanostructures II

ELEG 5353 Semiconductor Optoelectronic Devices

ELEG 5363 Semiconductor Material and Device Characterization

ELEG 5383 Introduction of Integrated Photonics

ELEG 5393 Electronic Materials

ELEG 5543 Introduction to Power Electronics

MEEG 5263 Introduction to Micro Electro Mechanical Systems

MEEG 5343 Computational Material Science

MSEN 6323 Materials Engineering Design

PHYS 5713 Condensed Matter Physics I

PHYS 5734 Laser Physics

PHYS 5753 Applied Nonlinear Optics

PHYS 5773 Introduction to Optical Properties of Materials

PHYS 6613 Quantum Optics

PHYS 6713 Condensed Matter Physics II

## Concentration in Nanoscale Materials & Devices

Course List

Choose nine hours of the following: 9

CHEM 5443 Physical Chemistry of Materials

ELEG 4303 Introduction to Nanomaterials and Devices

MEEG 5323 Physical and Chemical Vapor Deposition Processes

MEEG 5333 Introduction to Tribology

MEEG 5343 Computational Material Science

MSEN 5713 Advanced Nanomaterials Chemistry

MSEN 5733L Fabrication at the Nanoscale

MSEN 6323 Materials Engineering Design

PHYS 5713 Condensed Matter Physics I

PHYS 5723 Physics at the Nanoscale

PHYS 5783 Physics of 2D Materials

PHYS 6713 Condensed Matter Physics II

## Concentration in Materials Modeling

Course List

Choose nine hours of the following: 9

CVEG 5383 Finite Element Methods in Civil Engineering

MEEG 5123 Finite Elements Methods II

MEEG 5343 Computational Material Science

MEEG 5733 Advanced Numerical Methods

MSEN 6323 Materials Engineering Design

PHYS 5093 Applications of Group Theory to Physics

PHYS 5363 Scientific Computation and Numerical Methods

PHYS 5713 Condensed Matter Physics I

PHYS 6713 Condensed Matter Physics II