# MATERIALS SCIENCE AND ENGINEERING, BSE

**Degree:** Bachelor of Science in Engineering (BSE)
**Major:** Materials Science and Engineering

## Program Overview

The curriculum leading to the Bachelor of Science in Engineering degree with a major in Materials Science and Engineering includes the "Engineering Core" – basic courses in mathematics, physics, chemistry, and engineering along with breadth electives – and the CWRU General Education requirements. To these are added courses in engineering materials, which also allow students to choose one of several areas of concentration within the major. A total of 128 credit hours is required.

Throughout the undergraduate curriculum in Materials Science and Engineering, scientific fundamentals are integrated with coverage of current manufacturing, design, and applications of engineering materials.

The goal of the Department of Materials Science and Engineering is to prepare students for rewarding careers that provide creative, effective solutions to societal needs, through coursework and associated activities that emphasize:

- The interrelationships among the processing, structure, properties, and performance of engineering materials
- The mutual reinforcement of education and professional development throughout one's career

The undergraduate experience in Materials Science and Engineering at Case Western Reserve is marked by a high degree of hands-on experience and many opportunities for professional development before graduation. Lab courses, senior projects, and plant tours ensure that every student sees the field first-hand in current research and industrial settings.

The Bachelor of Science in Engineering degree program with a major in Materials Science and Engineering is accredited by the Engineering Accreditation Commission of ABET.

## Program Educational Objectives

a. Graduates will take an active part in professional organizations.
b. Graduates will assume leadership positions in materials science related industries.
c. Graduates will be effectively involved in solving technical problems.
d. Graduates may successfully enter and complete graduate and professional degree programs.

## Learning Outcomes

As preparation for achieving the above educational objectives, the Bachelor of Science in Engineering degree program with a major in Materials Science and Engineering is designed so that students attain:

- an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
- an ability to communicate effectively with a range of audiences
- an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
- an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
- an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
- an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

## Co-op and Internship Programs

Opportunities are available for students to alternate studies with work in industry or government as a co-op student, which involves paid full-time employment over seven months (one semester and one summer). Students may work in one or two co-ops, beginning in the third year of study. Co-ops provide students the opportunity to gain valuable hands-on experience in their field by completing a significant engineering project while receiving professional mentoring. During a co-op placement, students do not pay tuition but maintain their full-time student status while earning a salary. Alternatively or additionally, students may obtain employment as summer interns.

## Undergraduate Policies

For undergraduate policies and procedures, please review the Undergraduate Academics section of the General Bulletin.

## Accelerated Master's Programs

Undergraduate students may participate in accelerated programs toward graduate or professional degrees. For more information and details of the policies and procedures related to accelerated studies, please visit the Undergraduate Academics section of the General Bulletin.

## Program Requirements

Students seeking to complete this major and degree program must meet the general requirements for bachelor's degrees and the Unified General Education Requirements. Students completing this program as a secondary major while completing another undergraduate degree program do not need to satisfy the school-specific requirements associated with this major.

Students majoring in Materials Science and Engineering have six concentrations available to them, or the option to double major with Biomedical Engineering or Mechanical Engineering.

- Materials Science and Engineering with Concentrations
    - Biomaterials Concentration
    - Electronic Materials Concentration
    - Materials Data Science Concentration
    - Polymers Concentration

- Structural Materials and Mechanical Behavior Concentration
- Advanced Materials Science and Engineering Concentration

- Materials Science and Engineering with double major in Biomedical Engineering
- Materials Science and Engineering with double major in Mechanical Engineering

Each option has a different set of required courses, which are presented in the tables below. The major provides the student with both a foundational background in materials science and engineering and allows flexibility to concentrate studies in a well-defined area. To meet specific educational objectives, students may choose alternatives from among the suggested electives or design unique specialties. These options are flexible and subject to departmental guidelines and faculty approval. The choices for double majors are limited because the curriculum is specified so that students can successfully complete the degree requirements for a single B.S.E. degree with a double major in Materials Science and Engineering and Biomedical or Mechanical Engineering degrees within a four-year period.

## Required Courses

| Code | Title | Hours |
|---|---|---|
| **Required Mathematics, Science and Engineering Courses** | | |
| MATH 121 | Calculus for Science and Engineering I | 4 |
| MATH 122 | Calculus for Science and Engineering II | 4 |
| or MATH 124 | Calculus II | |
| MATH 223 | Calculus for Science and Engineering III | 3 |
| or MATH 227 | Calculus III | |
| MATH 224 | Elementary Differential Equations | 3 |
| or MATH 228 | Differential Equations | |
| PHYS 121 | General Physics I - Mechanics | 4 |
| or PHYS 123 | Physics and Frontiers I - Mechanics | |
| PHYS 122 | General Physics II - Electricity and Magnetism | 4 |
| or PHYS 124 | Physics and Frontiers II - Electricity and Magnetism | |
| CHEM 111 | Principles of Chemistry for Engineers | 4 |
| ENGR 130 | Foundations of Engineering and Programming | 3 |
| ENGR 145 | Chemistry of Materials | 4 |
| ENGR 200 | Statics and Strength of Materials | 3 |
| ENGR 210 | Introduction to Circuits and Instrumentation | 4 |
| ENGR 225 | Thermodynamics, Fluid Dynamics, Heat and Mass Transfer | 4 |

| Code | Title | Hours |
|---|---|---|
| **Foundational Materials Engineering:** | | |
| EMSE 327 | Thermodynamic Stability and Rate Processes | 3 |
| EMSE 276 | Materials Properties: Composition and Structure | 3 |
| EMSE 319 | Processing and Manufacturing of Materials | 3 |
| EMSE 328 | Mesoscale Structural Control of Functional Materials | 3 |
| EMSE 379 | Design for Lifetime Performance | 3 |
| **Mathematical Methods Requirement** [a] | | |
| EMSE 228 | Mathematical and Computational Methods for Materials Science and Engineering | 3 |
| or EMAE 250 | Computers in Mechanical Engineering | |
| or EBME 309 | Modeling of Biomedical Systems | |
| **Applied Materials Science to Applications** | | |
| EMSE 343 | Processing of Electronic Materials | 3 |
| EMSE 345 | Engineered Materials for Biomedical Applications | 3 |
| EMSE 349 | Role of Materials in Energy and Sustainability | 3 |
| EMSE 372 | Structural Materials by Design | 4 |
| **Applied Engineering Concepts** [a] | | |
| EMSE 110 | Transitioning Ideas to Reality I - Materials in Service of Industry and Society [b] | 1 |
| EMSE 120 | Transitioning Ideas to Reality II - Manufacturing Laboratory [b] | 2 |
| EMSE 220 | Materials Laboratory I [b] | 2 |
| EMSE 320 | Materials Laboratory II [b] | 1 |
| EMSE 330 | Materials Laboratory III [b] | 2 |
| **Senior Writing Capstone** [a] | | |
| EMSE 398 | Senior Project in Materials I [b] | 1 |
| EMSE 399 | Senior Project in Materials II | 2 |
| or EMAE 398 | Senior Project | |
| or EBME 380 | Biomedical Engineering Design Experience | |
| Concentration Sequence | | 18 |
| **Total Hours** | | **60** |

a Courses in these sections vary based on concentration or double major.

b Course waived for students completing either the Biomedical Engineering double major or the Mechanical Engineering double major.

# Double Major in Materials Science and Engineering and Biomedical Engineering

This double major is jointly administered by the Department of Biomedical Engineering and the Department of Materials Science and Engineering. The double major educates and prepares undergraduate students for leadership roles in the application of Materials Engineering to solve challenges in Biomedical Engineering. Achievements that combine these engineering disciplines underpin the revolutionary advances in technology and medicine that define the modern standard of healthy living. See the Plan of Study tab for a sample curriculum plan, and the Biomedical Engineering, BSE page for the Biomedical Engineering major requirements.

# Double Major in Materials Science and Engineering and Mechanical Engineering

This double major is jointly administered by the Department of Mechanical and Aerospace Engineering and the Department of Materials Science and Engineering. The double major educates and prepares undergraduate students for leadership roles in the application of Materials Engineering to solve challenges in Mechanical Engineering. Achievements that combine these engineering disciplines underpin the revolutionary advances in technology that define the industrialized economy. See the Plan of Study tab for a sample curriculum plan, and the Mechanical Engineering, BSE page for the Mechanical Engineering major requirements.

# Concentration Requirements

The undergraduate program has six concentration sequences that expose students to greater depth in areas related to materials science and engineering and are based on an application or subfield of engineering materials.

Each concentration is a coherent set of courses that, in conjunction with one or more of the courses already required for all EMSE majors plus a specified mathematics/natural science/statistics course, will provide significant depth in an area of materials specialization. The Advanced Materials Science and Engineering sequence is designed in consultation with their advisors and subject to approval by the department's Undergraduate Studies Committee.

The concentrations are below. All concentrations have 6 credit hours of EMAC courses and 12 credit hours of technical elective choices.

## Biomaterials Concentration

| Code | Title | Hours |
|---|---|---|
| **Required Courses:** | | |
| EMAC 270 | Introduction to Polymer Science and Engineering | 3 |
| EMAC 276 | Polymer Properties and Design | 3 |
| EBME 201 | Physiology-Biophysics I | 3 |
| EBME 202 | Physiology-Biophysics II | 3 |
| **Choose two of the following:** | | **6** |
| EBME/EMAC 303 | Structure of Biological Materials | |
| EBME 305 | Materials for Prosthetics and Orthotics | |
| EBME 306 | Introduction to Biomedical Materials | |
| EBME 316 | Biomaterials for Drug Delivery | |
| EBME 325 | Introduction to Tissue Engineering | |
| EBME 406/ EMAC 471 | Polymers in Medicine | |
| EBME/ECSE 480B | The Human Body | |
| **Total Hours** | | **18** |

## Electronic Materials Concentration

| Code | Title | Hours |
|---|---|---|
| **Required Courses:** | | |
| EMAC 270 | Introduction to Polymer Science and Engineering | 3 |
| EMAC 276 | Polymer Properties and Design | 3 |
| PHYS 221 | Introduction to Modern Physics ** | 3 |
| **Choose three of the following:** [a] | | **9-10** |
| *Emphasis on Solid-State Physics Courses* | | |
| PHYS 315 | Introduction to Solid State Physics | |
| PHYS 326 | Physical Optics | |
| PHYS 327 | Laser Physics | |
| PHYS 331 | Introduction to Quantum Mechanics I | |
| *Emphasis on Electronic Device Technology Courses* | | |
| CHEM 340 | Solar Energy Conversion | |
| ECHE 383 | Chemical Engineering Applied to Microfabrication and Devices | |
| ECSE 309 | Electromagnetic Fields I | |
| ECSE 321 | Semiconductor Electronic Devices | |
| ECSE 322 | Integrated Circuits and Electronic Devices | |
| EMSE 427 | Defects in Solids | |
| **Total Hours** | | **18** |

a Courses can be any combination from the two listed categories.

## Materials Data Science Concentration

| Code | Title | Hours |
|---|---|---|
| **Required Courses:** | | |
| DSCI 351M | Exploratory Data Science | 3 |
| EMAC 270 | Introduction to Polymer Science and Engineering | 3 |
| EMAC 276 | Polymer Properties and Design | 3 |
| STAT 312R | Basic Statistics for Engineering and Science Using R Programming | 3 |
| **Choose one of the following:** | | **3** |
| DSCI 352M | Applied Data Science Research | |
| DSCI 353M | Data Science: Statistical Learning, Modeling and Prediction | |
| **Choose one of the following:** | | **3** |
| ECSE 321 | Semiconductor Electronic Devices | |
| ECSE 322 | Integrated Circuits and Electronic Devices | |
| MATH 307 | Linear Algebra | |
| MATH 304 | Discrete Mathematics | |
| **Total Hours** | | **18** |

## Polymers Concentration [a]

| Code | Title | Hours |
|---|---|---|
| **Required Courses:** | | |
| EMAC 270 | Introduction to Polymer Science and Engineering | 3 |
| EMAC 276 | Polymer Properties and Design | 3 |
| CHEM 223 | Introductory Organic Chemistry I | 3 |
| or CHEM 323 | Organic Chemistry I | |
| **Choose three of the following:** | | **9** |
| EMAC 351 | Physical Chemistry for Engineering | |
| EMAC 355 | Polymer Analysis Laboratory | |
| EMAC 372 | Polymer Processing and Testing Laboratory | |
| EMAC 375 | Fundamentals of Non-Newtonian Fluid Mechanics and Polymer Rheology | |
| EMAC 376 | Polymer Engineering | |
| EMAC 377 | Polymer Processing | |
| **Total Hours** | | **18** |

a Completion of the Polymers Concentration satisfies the requirements for a minor in Polymer Science and Engineering.

## Structural Materials and Mechanical Behavior Concentration

| Code | Title | Hours |
|---|---|---|
| **Required Courses:** | | |
| EMAC 270 | Introduction to Polymer Science and Engineering | 3 |
| EMAC 276 | Polymer Properties and Design | 3 |
| STAT 312 | Basic Statistics for Engineering and Science | 3 |
| **Choose three of the following:** | | **9** |

| | | |
|---|---|---|
| ECHE 481 | Corrosion Fundamentals | |
| ECIV 310 | Strength of Materials | |
| EMAE 370 | Design of Mechanical Elements | |
| EMAE 480 | Fatigue of Materials | |
| EMSE 417 | Properties of Materials in Extreme Environments | |
| EMSE 421 | Fracture of Materials | |
| EMSE 422 | Failure Analysis | |
| EMSE 427 | Defects in Solids | |
| **Total Hours** | | **18** |

## Advanced Materials Science and Engineering Concentration

Students may satisfy the concentration requirement by taking 15 credit hours of courses from engineering, math, statistics, or natural sciences departments (beyond those specifically required in the curriculum) at the 300 level or above, plus a course to satisfy the Mathematics/Natural Sciences/Statistics requirement in the Engineering Core. The courses are to be selected in consultation with the student's advisor and will be subject to approval by the department's Undergraduate Studies Committee. This option is appropriate for students who desire a further study in topics relevant to materials science and engineering that are not represented in the specializations listed above.

# Sample Plan of Study

The following is a suggested program of study. Current students should always consult their advisers and their individual graduation requirement plans as tracked in SIS.

# Materials Science and Engineering Plan of Study

| | | |
|---|---|---|
| **First Year** | | |
| **Fall** | | **Hours** |
| EMSE 110 | Transitioning Ideas to Reality I - Materials in Service of Industry and Society | 1 |
| MATH 121 | Calculus for Science and Engineering I | 4 |
| CHEM 111 | Principles of Chemistry for Engineers | 4 |
| ENGR 130 | Foundations of Engineering and Programming | 3 |
| Academic Inquiry Seminar, Breadth, or Elective course [a] | | 3 |
| | **Hours** | **15** |
| **Spring** | | |
| MATH 122 | Calculus for Science and Engineering II | 4 |
| ENGR 145 | Chemistry of Materials | 4 |
| PHYS 121 or PHYS 123 | General Physics I - Mechanics or Physics and Frontiers I - Mechanics | 4 |
| EMSE 120 | Transitioning Ideas to Reality II - Manufacturing Laboratory | 2 |
| Academic Inquiry Seminar, Breadth, or Elective course [a] | | 3 |
| | **Hours** | **17** |
| **Second Year** | | |
| **Fall** | | |
| MATH 223 or MATH 227 | Calculus for Science and Engineering III or Calculus III | 3 |
| PHYS 122 or PHYS 124 | General Physics II - Electricity and Magnetism or Physics and Frontiers II - Electricity and Magnetism | 4 |
| EMSE 276 | Materials Properties: Composition and Structure | 3 |
| EMAC 270 | Introduction to Polymer Science and Engineering | 3 |
| Breadth, or Elective course [a] | | 3 |
| | **Hours** | **16** |
| **Spring** | | |
| ENGR 399 | Impact of Engineering on Society | 3 |
| MATH 224 or MATH 228 | Elementary Differential Equations or Differential Equations | 3 |
| ENGR 200 | Statics and Strength of Materials | 3 |
| EMSE 220 | Materials Laboratory I | 2 |
| EMSE 228 | Mathematical and Computational Methods for Materials Science and Engineering | 3 |
| Breadth, or Elective course [a] | | 3 |
| | **Hours** | **17** |
| **Third Year** | | |
| **Fall** | | |
| ENGR 225 | Thermodynamics, Fluid Dynamics, Heat and Mass Transfer | 4 |
| EMSE 320 | Materials Laboratory II | 1 |
| EMSE 328 | Mesoscale Structural Control of Functional Materials | 3 |
| EMSE 372 | Structural Materials by Design | 4 |
| Concentration course | | 3 |
| | **Hours** | **15** |
| **Spring** | | |
| ENGR 210 | Introduction to Circuits and Instrumentation | 4 |
| EMAC 276 | Polymer Properties and Design | 3 |
| EMSE 327 | Thermodynamic Stability and Rate Processes | 3 |
| EMSE 330 | Materials Laboratory III | 2 |
| Breadth, or Elective course [a] | | 3 |
| Concentration course | | 3 |
| | **Hours** | **18** |
| **Fourth Year** | | |
| **Fall** | | |
| EMSE 398 | Senior Project in Materials I | 1 |
| EMSE 343 | Processing of Electronic Materials | 3 |
| EMSE 345 | Engineered Materials for Biomedical Applications | 3 |
| EMSE 349 | Role of Materials in Energy and Sustainability | 3 |
| Breadth, or Elective course [a] | | 3 |
| Concentration course | | 3 |
| | **Hours** | **16** |
| **Spring** | | |
| EMSE 399 | Senior Project in Materials II | 2 |

| | | |
|---|---|---|
| EMSE 319 | Processing and Manufacturing of Materials | 3 |
| EMSE 379 | Design for Lifetime Performance | 3 |
| Breadth, or Elective course [a] | | 3 |
| Concentration course | | 3 |
| | **Hours** | **14** |
| | **Total Hours** | **128** |

a Unified General Education Requirement.

# Double Major in Materials Science and Engineering and Biomedical Engineering Plan of Study

| | | |
|---|---|---|
| **First Year** | | |
| **Fall** | | **Hours** |
| MATH 121 | Calculus for Science and Engineering I | 4 |
| CHEM 111 | Principles of Chemistry for Engineers | 4 |
| ENGR 130 | Foundations of Engineering and Programming | 3 |
| Academic Inquiry Seminar, Breadth, or Elective course [a] | | 3 |
| Breadth, or Elective course [a] | | 3 |
| | **Hours** | **17** |
| **Spring** | | |
| MATH 122 | Calculus for Science and Engineering II | 4 |
| PHYS 121 | General Physics I - Mechanics | 4 |
| ENGR 145 | Chemistry of Materials | 4 |
| Academic Inquiry Seminar, Breadth, or Elective course [a] | | 3 |
| Breadth, or Elective course [a] | | 3 |
| | **Hours** | **18** |
| **Second Year** | | |
| **Fall** | | |
| MATH 223 | Calculus for Science and Engineering III | 3 |
| PHYS 122 | General Physics II - Electricity and Magnetism | 4 |
| CHEM 223 | Introductory Organic Chemistry I | 3 |
| EMSE 276 | Materials Properties: Composition and Structure | 3 |
| EBME 201 | Physiology-Biophysics I | 3 |
| Breadth, or Elective course [a] | | 3 |
| | **Hours** | **19** |
| **Spring** | | |
| MATH 224 | Elementary Differential Equations | 3 |
| ENGR 200 | Statics and Strength of Materials | 3 |
| ENGR 210 | Introduction to Circuits and Instrumentation | 4 |
| EBME 202 | Physiology-Biophysics II | 3 |
| STAT 312 | Basic Statistics for Engineering and Science | 3 |
| | **Hours** | **16** |
| **Third Year** | | |
| **Fall** | | |
| EMAC 270 | Introduction to Polymer Science and Engineering | 3 |
| EMAC 351 | Physical Chemistry for Engineering | 3 |
| EMSE 328 | Mesoscale Structural Control of Functional Materials | 3 |
| EBME 306 & EBME 356 | Introduction to Biomedical Materials and Introduction to Biomaterials Engineering - Laboratory | 4 |
| EBME 308 & EBME 358 | Biomedical Signals and Systems and Biomedical Signals and Systems Laboratory | 4 |
| | **Hours** | **17** |
| **Spring** | | |
| EBME 310 & EBME 360 | Principles of Biomedical Instrumentation and Biomedical Instrumentation Laboratory | 4 |
| EBME 309 & EBME 359 | Modeling of Biomedical Systems and Biomedical Computer Simulation Laboratory | 4 |
| EMSE 327 | Thermodynamic Stability and Rate Processes | 3 |
| EMAC 352 | Polymer Physics and Engineering | 3 |
| ENGR 399 | Impact of Engineering on Society | 3 |
| | **Hours** | **17** |
| **Fourth Year** | | |
| **Fall** | | |
| EBME 370 | Principles of Biomedical Engineering Design | 3 |
| EMSE 343 | Processing of Electronic Materials | 3 |
| EMSE 372 | Structural Materials by Design | 4 |
| EMSE 345 | Engineered Materials for Biomedical Applications | 3 |
| Breadth, or Elective course [a] | | 3 |
| | **Hours** | **16** |
| **Spring** | | |
| EBME 380 | Biomedical Engineering Design Experience | 3 |
| EBME 305 | Materials for Prosthetics and Orthotics | 3 |
| EMSE 379 | Design for Lifetime Performance | 3 |
| EMSE 319 | Processing and Manufacturing of Materials | 3 |
| Breadth, or Elective course [a] | | 3 |
| Breadth, or Elective course [a] | | 3 |
| | **Hours** | **18** |
| | **Total Hours** | **138** |

a Unified General Education Requirement.

# Double Major in Materials Science and Engineering and Mechanical Engineering Plan of Study

**First Year**

| Fall | | Hours |
|---|---|---|
| CHEM 111 | Principles of Chemistry for Engineers | 4 |
| MATH 121 | Calculus for Science and Engineering I | 4 |
| PHYS 121 | General Physics I - Mechanics | 4 |
| Academic Inquiry Seminar, Breadth, or Elective course [a] | | 3 |
| Breadth, or Elective course [a] | | 3 |
| | **Hours** | **18** |
| **Spring** | | |
| MATH 122 | Calculus for Science and Engineering II | 4 |
| PHYS 122 | General Physics II - Electricity and Magnetism | 4 |
| ENGR 130 | Foundations of Engineering and Programming | 3 |
| ENGR 145 | Chemistry of Materials | 4 |
| Academic Inquiry Seminar, Breadth, or Elective course [a] | | 3 |
| | **Hours** | **18** |

**Second Year**

| Fall | | |
|---|---|---|
| MATH 223 or MATH 227 | Calculus for Science and Engineering III or Calculus III | 3 |
| EMSE 276 | Materials Properties: Composition and Structure | 3 |
| EMAE 160 | Mechanical Manufacturing | 3 |
| ENGR 200 | Statics and Strength of Materials | 3 |
| Breadth, or Elective course [a] | | 3 |
| Breadth, or Elective course [a] | | 3 |
| | **Hours** | **18** |
| **Spring** | | |
| ENGR 210 | Introduction to Circuits and Instrumentation | 4 |
| MATH 224 | Elementary Differential Equations | 3 |
| EMAE 181 | Dynamics | 3 |
| EMAE 251 | Thermodynamics | 3 |
| EMAE 250 | Computers in Mechanical Engineering | 3 |
| STAT 312 | Basic Statistics for Engineering and Science | 3 |
| | **Hours** | **19** |

**Third Year**

| Fall | | |
|---|---|---|
| EMAE 252 | Fluid Mechanics | 3 |
| ECIV 310 | Strength of Materials | 3 |
| EMSE 372 | Structural Materials by Design | 4 |
| EMSE 328 | Mesoscale Structural Control of Functional Materials | 3 |
| EMAE 350 | Mechanical Engineering Analysis | 3 |
| | **Hours** | **16** |
| **Spring** | | |
| EMSE 327 | Thermodynamic Stability and Rate Processes | 3 |
| EMAE 260 | Design and Manufacturing I | 3 |
| EMAE 353 | Heat Transfer | 3 |
| EMAE 285 | Mechanical Engineering Measurements Laboratory | 4 |
| EMAE 370 | Design of Mechanical Elements | 3 |
| | **Hours** | **16** |

**Fourth Year**

| Fall | | |
|---|---|---|
| EMAE 355 | Design of Fluid and Thermal Elements | 3 |
| EMAE 360 | Design and Manufacturing II | 3 |
| EMAE 351 | Control of Mechanical Systems | 3 |
| EMSE 343 or EMSE 345 | Processing of Electronic Materials or Engineered Materials for Biomedical Applications | 3 |
| EMSE 349 | Role of Materials in Energy and Sustainability | 3 |
| Breadth, or Elective course [a] | | 3 |
| | **Hours** | **18** |
| **Spring** | | |
| EMSE 319 | Processing and Manufacturing of Materials | 3 |
| EMAE 398 | Senior Project | 3 |
| EMSE 379 | Design for Lifetime Performance | 3 |
| ENGR 399 | Impact of Engineering on Society | 3 |
| Breadth, or Elective course [a] | | 3 |
| | **Hours** | **15** |
| | **Total Hours** | **138** |

a Unified General Education Requirement.