Elective Concentrations

The program in Mechanical Engineering is designed to appeal to students with a wide variety of interests and professional goals. By an appropriate choice of elective courses, students can develop a highly personalized curriculum.

Some suggested areas of concentration are biomedical engineering, design, energy and sustainability, intelligent mechanical systems, and computer-aided design/computer-aided manufacturing.

The biomedical engineering concentration is open to students interested in the biological and medical application of mechanical engineering procedures. Students may also want to consider the “pre-medical” concentration (below).

The design concentration focuses on product design supported by innovations, systematic design processes, and computational design methods while incorporating manufacturing and other life cycle considerations.

The energy and sustainability concentration emphasizes the mechanical aspects of energy conversion and management.

The manufacturing concentration is directed toward planning and selecting manufacturing methods, design for manufacture, computer-aided flexible automation and robotics, digital manufacturing, and increasing the efficiency and productivity of current and emerging manufacturing technologies.

The MEMS/Nanotechnology concentration focuses on the design and performance of nano and microscale devices, and materials behavior at these length-scales.

The robotics concentration focuses on robotics and the design of microprocessor-controlled electromechanical systems.

The solid mechanics concentration focuses on the study of stress and strain in solid bodies along with the application of computational methods for stress analysis.

The thermo-fluids concentration is appropriate for students with an interest in one of the wide array of technologies where fluid flow and heat transport are the dominant physical mechanisms.

The pre-medical concentration is open to students interested in obtaining an ME degree while also satisfying the requirements for admission to medical school.

It is possible that technical electives chosen according to the suggested concentrations below may not include two 300-level ME courses. This is acceptable provided that the technical electives satisfy the requirements of one of the areas of concentration.
Biomedical Engineering Concentration – 4 courses

Choose one of the options below.

Required for all options:

One 300-level course in mathematics or basic sciences.

Option 1: Biological Mechanics and Rehabilitation

Take both of these courses:
- BME 371 Mechanics of Biological Tissues
- BME 366 Biomechanics of Movement

Choose one of these courses:
- ME 314* Theory of Machines – Dynamics*
- EECS 360* Introduction to Feedback Systems*
- ME 333 Mechatronics
- ME 433 Advanced Mechatronics
- ME 449 Robotic Manipulation
- ME 454 Opt. Control of Nonlinear Systems
- ME 495 Embedded Systems in Robotics

Option 2: Neural Engineering and Artificial Intelligence

Required basic math and science:
- BIO 302 Fundamentals of Neurobiology I

Choose one of these courses:
- ME 314* Theory of Machines - Dynamics*
- EECS 360* Introduction to Feedback Systems* ME 333 Mechatronics
- ME 433 Advanced Mechatronics

Choose one of these courses:
- EECS 325 Artificial Intelligence Programming
- EECS 332 Digital Image Analysis
- EECS 348 Intro to Artificial Intelligence
- EECS 349 Machine Learning
- EECS 495 Machine Learning & AI for Robots

Choose one of these courses:
- BME 365 Ctrl of Human Limbs…
- BME 461 Computational Neuromechanics…
- BME 462 Sensory Acquisition
- BME 463 Systems Neuropathophysiology
- BME 465 Mdlng & Sim Human Movement
- BME 467 Biomedical Robotics
- BME 469 Neural Control & Mech of Mvment

Option 3: Biomaterials and regenerative medicine

Choose one of these three:
- BME 343 Biomaterials and Medical Devices
- MSCI 370 Biomat.
- BME 344 Biol. Performance of Materials

Choose one of these two:
- BME 346 Tissue Engineering
- BME 349 Bioregenerative Engineering

Choose one from the following list:
- ChBE 361 Introduction to Polymers
- ChBE 379 Comp. Bio: Principles & Applications
- MSCI 318 Materials Selection
- MSCI 376 Nanomaterials
Option 4: Imaging and biophotonics

Required:
BME 325 Introduction to Medical Imaging

Choose one of these two:
BME 327 Magnetic Resonance Imaging
BME 333 Modern Opt. Micro. and Imaging

Choose one from the following list:
EECS 302 Prob. Systems and Random Signals
EECS 328 Numerical Methods for Engineers
EECS 332 Digital Image Analysis
EECS 360 Introduction to Feedback Systems
EECS 379 Lasers and Coherent Optics
EECS 382 Photonic Information Processing
EECS 395 Bioinformatics

Option 5: Biological fluids and transport

Required:
BME 350 Transport Fundamentals

Choose two from the following list:
ME 322* Thermodynamics II*                  ME 373* Engr. Fluid Mechanics*
ME 420 Micro & Nano Fluid Dynamics
ME 423 Intro to Comp. Fluid Dynamics
ME 424 Advanced Comp. Fluid Dynamics
ME 425 Introduction to Fluid Dynamics
ME 427 Viscous Fluid Mechanics
BME 450 Mass and Heat Transfer
BME 452 Transport Connective Tissues

* If not taken to satisfy the Advanced Study requirement
Design Concentration - 4 courses

**Required:** One 300-level course in mathematics or basic sciences.

**Take any three from the following list:**
- ME 333 Introduction to Mechatronics
- ME 340-2 Computer Integrated Manufacturing
- ME 341 Computational Methods for Engineering Design
- ME 346 Introduction to Tribology
- ME 359 Reliability Engineering
- ME 365 Finite Elements for Stress Analysis (if not included as an ME Advanced Study course)
- ME 366 Finite Elements for Design and Optimization
- MSc 318 Materials Selection
- IEMS 307 Quality Improvement by Experimental Design
- DSGN 3xx Any 300-level DSGN course *(Note: Only one DSGN 3xx may count as a Tech Elective)*

Energy and Sustainability Concentration - 4 courses

ISEN stands for the Institute for Sustainability and Energy at Northwestern

Note that ISEN 200-level courses cannot count as concentration courses, but may be taken as unrestricted electives.

**Required:** One 300-level course in mathematics or basic sciences.

**Choose two from the following list:**
- ME 322* OR ME 373*: Thermodynamics II* OR Engineering Fluid Mechanics*  
  (* whichever is not taken as an ME Advanced Study course)
- ME 395*: Quantitative Methods in Life Cycle Analysis
- ME 395*/ISEN 395*: Thermal Energy Systems Design
- ME 395*: Energy Systems
- ME 495*/ISEN 495*: Industrial Energy Management and Utilization
- ME 495*: Sustainable Manufacturing Systems

**Choose one from the following list:**
- ISEN 410: Topics in Contemporary Energy and Climate Change
- ISEN 430: NUvention Energy
- CHEM_ENG 365: Sustainability, Technology and Society
- CIV_ENV 368: Sustainability: Issues and Actions Near and Far
- MAT_SCI 381: Materials for Energy-Efficient Technology

If the course in basic math and science is 300-level or above, then one of the three other courses may be 200 level. An interesting choice here may be CIV_ENV 203: Energy and the Environment: The Automobile

*Note: The course numbers 395 and 495 are used as “generic” numbers for any course that does not yet have a permanent, unique number within the department. The fact that these particular 395 and 495 courses – with these particular titles – can count towards the “energy and sustainability concentration” should not be taken to indicate that all ME 395 courses can count towards the concentration.
**Manufacturing Concentration - 4 courses**

**Required:** One 300-level course in mathematics or basic sciences.

**Take one course from each of the following three groups:**

**Group 1:**
- ME 340-2 Computer-Integrated Manufacturing: CAD/CAM
- ME 340-3 Computer-Integrated Manufacturing: Automation

**Group 2:**
- ME 346 Introduction to Tribology
- EECS 390 Introduction to Robotics
- MSc 317 Materials in Manufacturing
- MSc 331 Soft materials
- MSc 340 Ceramic Processing

**Group 3:**
- ME 341 Computational Methods for Engineering Design
- ME 366 Finite Elements in Design Optimization
- EECS 360 Introduction to Feedback Systems
- ME 359 Reliability Engineering
- IEMS 305 Statistical Methods for Quality Improvement
- IEMS 307 Quality Improvement by Experimental Design

**MEMS/Nanotechnology Concentration – 4 courses**

**Required:** One 300-level course in mathematics or basic sciences.

**Take three classes from the list below:**

- ME 381 Introduction to MEMS
- ME 382 Experiments in Micro/Nano Science and Engineering
- ME 451 Micromachining
- EECS 388 Nanotechnology
- ME-CEE Finite Element Method
- ME 417 Multi-scale Modeling and Simulation in Solid Mechanics
- ME 418 Multi-scale Modeling and Simulation in Fluid Mechanics
- MAT_SCI 376 Nanomaterials
- MAT_SCI 455 Solid State Physics of Nanomaterials
- ME 420 Micro and Nano-Scale Fluid Dynamics
- ME 495 Computational Nanodynamics
Robotics Concentration – 4 courses

**Required:** One 300-level course in mathematics or basic sciences.

Some courses to consider that meet this requirement include:
- BIOL_SCI 302 Fundamentals of Neurobiology I
- BIOL_SCI 306 Fundamentals of Neurobiology II
- BIOL_SCI 322 Systems and Computational Neuroscience
  Any more advanced Neuroscience course (cannot be in the BME department, must be basic math/science)
- PSYCH 324 Perception
- PSYCH 335 Decision Making
- PSYCH 351 Advanced Statistics and Experimental Design
- CSD 306 Psychoacoustics
- CSD 310 Biological Foundations of Speech and Music
- PHYSICS 352 Introduction to Computational Physics
- PHYSICS 357 Optics Laboratory

**Required:**
- ME 333 Introduction to Mechatronics

**Take any two of these courses:**

**Courses that emphasize programming:**
- EECS 205 Fundamentals of Computer System Software
- EECS 211 A Fundamentals of Computer Programming 1
- EECS 211 B Fundamentals of Computer Programming 2
- EECS 230 Programming for Computer Engineers
- EECS 336 Design and Analysis of Algorithms
- EECS 457 Advanced Algorithms

**Courses that emphasize artificial intelligence:**
- EECS 325 Artificial Intelligence Programming
- EECS 332 Digital Image Analysis
- EECS 348 Intro to Artificial Intelligence
- EECS 349 Machine Learning
- EECS 495 Machine Learning and Artificial Intelligence for Robotics

**Courses that emphasize neuroscience:**
*NOTE: Only 1 from this group can count as a Technical Elective towards the ME degree*
- BME 365 Control of Human Limbs and Their Artificial Replacements
- BME 461 Computational Neuromechanics and Neuroethology
- BME 462 Sensory Acquisition
- BME 463 Systems Neuropathophysiology
- BME 465 Modeling and Simulation of Human Movement
- BME 467 Biomedical Robotics
- BME 469 Neural Control and Mechanics of Movement

**Courses that emphasize dynamics, mechatronics, robotics, and control:**
- ME 314 Theory of Machines - Dynamics
- ME 433 Advanced Mechatronics
- ME 449 Robotic Manipulation
- ME 454 Optimal Control of Nonlinear Systems
- ME 495 Embedded Systems in Robotics
- EECS 360 Introduction to Feedback Systems
- EECS 374 Intro to Digital Control
- EECS 390 Intro to Robotics
- EECS 410 System Theory
- EECS 495 Introduction to Nonlinear Control Theory
**Solid Mechanics Concentration – 4 courses**

**Required:** One 300-level course in mathematics or basic sciences.

**Take three classes from the list below:**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 362</td>
<td>Stress Analysis</td>
</tr>
<tr>
<td>CEE 319</td>
<td>Theory of Structures II (CEE 221 is a prerequisite)</td>
</tr>
<tr>
<td>CEE 320</td>
<td>Structural Analysis</td>
</tr>
<tr>
<td>ME 327 (CEE 327)</td>
<td>Finite Element Methods in Mechanics</td>
</tr>
<tr>
<td>ME 416</td>
<td>Computational Nanodynamics</td>
</tr>
<tr>
<td>ME 413</td>
<td>Experimental Solid Mechanics</td>
</tr>
<tr>
<td>ME 414</td>
<td>Mechanics of Composite Materials I</td>
</tr>
<tr>
<td>CEE 417</td>
<td>Mechanics of Continua I</td>
</tr>
<tr>
<td>ME 417</td>
<td>Multi-scale Modeling and Simulation in Solid Mechanics</td>
</tr>
<tr>
<td>ME426-I</td>
<td>Advanced Finite Element Methods</td>
</tr>
</tbody>
</table>

If the course in basic math and science is 300-level or above, then one of the three other courses may be 200 level. An interesting choice here may be ME 260, Mechanics of Sports.

**Thermo-fluids Concentration – 4 courses**

**Required:** One 300-level course in mathematics or basic sciences.

**Take three classes from the list below:**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 322</td>
<td>Thermodynamics II                         (if not taken as Advanced Study)</td>
</tr>
<tr>
<td>ME 373</td>
<td>Engineering Fluid Mechanics (if not taken as Advanced Study)</td>
</tr>
<tr>
<td>ME 420</td>
<td>Micro &amp; Nanoscale Fluid Dynamics</td>
</tr>
<tr>
<td>ME 423</td>
<td>Introduction to Computational Fluid Dynamics</td>
</tr>
<tr>
<td>ME 424</td>
<td>Advanced Computational Fluid Dynamics</td>
</tr>
<tr>
<td>ME 425</td>
<td>Introduction to Fluid Dynamics</td>
</tr>
<tr>
<td>ME 427</td>
<td>Viscous Fluid Mechanics</td>
</tr>
<tr>
<td>BME 450</td>
<td>Mass and Heat Transfer</td>
</tr>
<tr>
<td>BME 452</td>
<td>Transport through Connective Tissues</td>
</tr>
</tbody>
</table>
Pre-Medical Concentration

Be sure to meet with a pre-med advisor early in your undergraduate career.

Note that the pre-med concentration requires students to use their “unrestricted electives” to complete the med school requirements for organic chemistry and biology.

In addition to the requirements listed below, med schools generally require:

- One year of General Chemistry with lab
- One year of Physics with lab (EA sequence replaces Physics 135-1. Should take Physics 135-2 and 135-3)
- One year of English/writing intensive (EDC counts for 1 quarter +2 courses from English or Comp Lit departments)
- Two or three quarters of Calculus

Required:
One year of Organic Chemistry with lab
This serves as a basic math and science tech elective and 2 unrestricted electives

Do one of the following two options:

Option 1: (7 courses)
- BIOLSCI 215 – Genetics and Molecular Biology
- BIOLSCI 216 – Cell Biology
- BIOLSCI 217 - Physiology
- BIOLSCI 218 – Biochemistry
- BIOLSCI 220 – Genetic and Molecular Processes lab (0.3 credit)
- BIOLSCI 221 – Cellular Processes lab (0.3 credit)
- BIOLSCI 222 – Physiological Processes lab (0.3 credit)
Two 300-level ME tech electives

Option 2: (7.6 courses)
- BIOLSCI 215 – Genetics and Molecular Biology
- BIOLSCI 216 – Cell Biology
- BIOLSCI 218 – Biochemistry
- BIOLSCI 220 – Genetic and Molecular Processes lab (0.3 credit)
- BIOLSCI 221 – Cellular Processes lab (0.3 credit)
- BME 301, 302, 303 (all three courses are required by medical schools to replace BIO 217 and BIO 222)
One 300-level ME tech elective

The course schedule below assumes that a student begins with no A.P. credits. It shows one of several possible ways that a student could fulfill all degree requirements. If a student has some A.P. credits there is considerably more flexibility in the schedule. It is critical to meet with a pre-med advisor early to determine the best possible sequence of courses.

<table>
<thead>
<tr>
<th>Freshman</th>
<th>Sophomore</th>
<th>Junior</th>
<th>Senior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>Fall</td>
<td>Fall</td>
<td>Fall</td>
</tr>
<tr>
<td>EA1</td>
<td>EA4</td>
<td>BME 301</td>
<td>Physiology</td>
</tr>
<tr>
<td>Humanities</td>
<td>Humanities</td>
<td>Humanities</td>
<td>Humanities</td>
</tr>
<tr>
<td>Winter</td>
<td>Winter</td>
<td>Winter</td>
<td>Winter</td>
</tr>
<tr>
<td>General chemistry</td>
<td>Mat Sci 201 Materials Science</td>
<td>Organic Chemistry</td>
<td>EECS 360 Feedback Systems</td>
</tr>
<tr>
<td>Calculus</td>
<td>Bio 216 + Bio lab</td>
<td>ME 377 heat transfer</td>
<td>Humanities</td>
</tr>
<tr>
<td>EDC</td>
<td>Physics 135-2</td>
<td>Humanities</td>
<td>ME Capstone</td>
</tr>
<tr>
<td>Spring</td>
<td>Spring</td>
<td>Spring</td>
<td>Spring</td>
</tr>
<tr>
<td>EA3</td>
<td>ME 240 Dsgn &amp; Mftcturing</td>
<td>BME 303</td>
<td>Physiology</td>
</tr>
<tr>
<td>General chemistry</td>
<td>ME 222 Thermo</td>
<td>Organic Chemistry</td>
<td>ME Tech Elective</td>
</tr>
<tr>
<td>Calculus</td>
<td>Bio 218</td>
<td>ME 315 Dsgn of Elements</td>
<td>Humanities</td>
</tr>
<tr>
<td>EDC</td>
<td>Physics 135-3</td>
<td>ME 241 Fluids</td>
<td>ME Capstone</td>
</tr>
</tbody>
</table>