Undergraduate Designated Minors in the College of Engineering

Overview
Undergraduate students in the Carnegie Institute of Technology can elect to complete an interdisciplinary Designated Minor in addition to their regular majors for B.S. degrees. Designated minors have been added to the curriculum of the Carnegie Institute of Technology to promote flexibility and diversity among the college’s engineering students. Independent of a student’s major, he or she is able to pursue a selected designated minor from the following list:

• Additive Manufacturing
• Audio Engineering
• Automation and Controls
• Biomedical Engineering
• Colloids, Polymers and Surfaces Technology
• Electronic Materials
• Global Engineering
• Materials Science and Engineering
• Mechanical Behavior of Materials

An engineering student may elect to complete a CIT designated minor. Generally, the student takes all the required courses in an engineering major but uses electives to take courses needed to fulfill the requirements of the designated minor. Upon completion of the requirements of a CIT designated minor and the engineering degree, the minor is a formally recognized on the student’s transcript.

Each of the CIT designated minors is administered by a Program Committee consisting of faculty from all major engineering departments who serve as faculty advisors. Each Program Committee certifies the completion of requirements of the designated minor. But the student’s major department is responsible for approving the degree with a designated minor after reviewing a student’s entire academic record. Any substitution or departure from the published curriculum should be avoided. For example, non-technical courses may not be substituted for required technical courses or electives. Equivalent technical electives offered by a designated minor as substitutions for required courses in a major must be approved by the Head of the student’s major department.

Although a student generally can complete a designated minor without increasing the number of required units for graduation, early planning in electing a designated minor is important. A student also may find that some minors are more compatible than others with his/her major because of different relations between various major and minor requirements. The requirements for these CIT designated minors are listed below.

Additive Manufacturing Minor
The objective of the Minor in Additive Manufacturing is to provide the student with a background in the engineering science that applies to additive manufacturing (also known as 3D printing), from part design through additive processes, to properties and component performance. Particular emphasis is given to metals additive manufacturing, due to its rapidly growing impact on manufacturing across multiple industries, and the need for talent in this area. The minor is open to students in all engineering majors.

Students may not use any given course to satisfy simultaneously requirements in both their enrolled major and in this minor. Graduate courses counted towards this minor may not be (double) counted for a graduate degree.

Minor Coordinators
Prof. Jack Beuth, Director
Dr. Sandra DeVincent Wolf, Assoc. Director
Prof. Anthony Rollett, Assoc. Director

Departmental Contacts
Biomedical Engineering Robert Tilton
Chemical Engineering Aditya Khair
Civil and Environmental Engineering Mitchell Small
Electrical and Computer Engineering Diana Marculescu
Audio Engineering Minor

Tom Sullivan, Director and Faculty Advisor

This sequence is for candidates who are engineering majors with interest in and/or have background in music, recording, sound-editing and/or other music technology areas; or majors from any discipline in the university who have the above interests and who can meet the prerequisite requirements for the engineering courses in the minor.

Note: Students who do not have the requisite engineering/science/math background should investigate the Minor in Music Technology offered by the School of Music.

Course Requirements

Minimum units required for minor: 73-79

The student must have taken the appropriate prerequisite courses for the listed courses.

Prerequisite Courses, 0-3 units

Beginning Piano is required of students who do not pass a piano proficiency test.

Units
57-103 Elective Studio (Beginning Piano Class) 3

Music Courses, 40-43 units

Basic Harmony I is required of students who do not qualify for entrance into Harmony I, based on their scores on the theory placement test.

Units
57-101 Introduction to Music Technology 6
57-149 Basic Harmony I 9
or 57-152 Harmony I 9
57-173 Survey of Western Music History * 9
57-188 Repertoire and Listening for Musicians 1
57-337 Sound Recording 6
* co-requisite 57-188.

(choice two of the courses below) Units
15-322 Introduction to Computer Music 9
57-338 Sound Editing and Mastering 6
57-347 Electronic and Computer Music 6
57-438 Multitrack Recording 9

Technical Courses, 33 units

Other courses may be taken with the approval of the Audio Engineering Minor Advisor.

Units
33-114 Physics of Musical Sound 9
18-493 Electroacoustics ** 12
18-300 Fundamentals of Electromagnetics 12
18-341 Logic Design and Verification 12
18-370 Fundamentals of Control 12
18-491 Fundamentals of Signal Processing 12
** prerequisites 18-220 and 18-290.

(choice one of the courses below) Units
15-210 Parallel and Sequential Data Structures and Algorithms 12
or 15-214 Principles of Software Construction: Objects, Design, and Concurrency 12
18-320 Microelectronic Circuits + 12
18-349 Introduction to Embedded Systems ** 12
** prerequisite 18-240 and 18-213.
+ prerequisite 18-220.

Automation and Controls Minor

Erik Ydstie, Director and Faculty Advisor

Location: DH 4210A

The objective of the Designated Minor in Automation and Control Engineering is to expose CIT students to the breadth of knowledge required by the modern practice of control and automation. With this objective in mind, the requirements include not only two courses in control system analysis and design, but also courses on real-time computation, software engineering, hardware implementation, and applications. The minor is expected to attract primarily students from Chemical Engineering, Electrical and Computer Engineering, and Mechanical Engineering. The main interdisciplinary component of the minor is between engineering and computer science, although many opportunities exist for creating a program across several CIT departments.

Course Requirements

Minimum units required for minor: 54

The minor requires a minimum of six courses as described below.

Note: The course lists below are not necessarily current or complete. Appropriate courses not listed below may be counted toward the requirements for the minor upon approval by one of the departmental faculty advisors. Students interested in the Automation and Control Engineering Designated Minor are encouraged to look for applicable courses each semester in CIT, CS, and Robotics.

One basic control course:
18-370 Fundamentals of Control 12
24-451 Feedback Control Systems 12

One course on control system analysis and design:
06-708 Advanced Process Dynamics and Control 12

One course on computing and software
12-741 Data Management 6

Other courses as approved by Director and Faculty Advisor

One course on hardware implementation:
06-423 Unit Operations Laboratory 9
18-474 Embedded Control Systems 12
18-578 Mechatronic Design 12

One course on applications:
06-606 Computational Methods for Large Scale Process Design & Analysis 9
16-311 Introduction to Robotics 12
16-761 Mobile Robots 12
24-351 Dynamics 10
xx-xxx Independent project 12

One elective course:
xx-xxx Any course in the list above excluding the basic control course category 6-12
15-385 Introduction to Computer Vision 6
15-413 SEE 17-413 Software Engineering Practicum 12
15-440 Distributed Systems-Time Software 12
18-349 Introduction to Embedded Systems 12
18-491 Fundamentals of Signal Processing 12
24-341 Manufacturing Sciences 9

Other courses as approved
Biomedical Engineering Minor

Professor Conrad M. Zapanta, Associate Department Head of Undergraduate Education
czapanta@cmu.edu
www.bme.cmu.edu (http://www.bme.cmu.edu)

The minor program is designed for engineering students who desire exposure to biomedical engineering but may not have the time to pursue the Biomedical Engineering additional major. The program is also open to students of all colleges and is popular among science majors. In conjunction with other relevant courses, the program may provide a sufficient background for jobs or graduate study in biomedical engineering. Students interested in a medical career may also find this program helpful.

The Biomedical Engineering minor curriculum is comprised of three core courses and three electives. Students pursuing the minor may contact the BME Associate Head for Undergraduate Education (https://www.cmu.edu/bme/People/Faculty/profile/czapanta.html) or the Biomedical Engineering Undergraduate Program Coordinator (https://www.cmu.edu/bme/People/Administration/).

Requirements

Minimum units required for minor: 57

<table>
<thead>
<tr>
<th>Course Requirements</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>03-121 Modern Biology</td>
<td>9</td>
</tr>
<tr>
<td>or 03-151 Honors Modern Biology</td>
<td></td>
</tr>
<tr>
<td>42-101 Introduction to Biomedical Engineering</td>
<td>12</td>
</tr>
<tr>
<td>42-202 Physiology</td>
<td>9</td>
</tr>
<tr>
<td>42-xxx BME Elective (&gt; = 9 units). Any course offered by the Department of Biomedical Engineering numbered 42-300 or higher and worth at least 9 units</td>
<td></td>
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<tr>
<td>xx-xxx Elective I (&gt; = 9 units)</td>
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<tr>
<td>xx-xxx Elective II (&gt; = 9 units)</td>
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</tbody>
</table>

Some Special Topics, newly offered or intermittently offered 42-xxx may be acceptable as electives. Students should consult with their advisors and petition the Biomedical Engineering Undergraduate Affairs Committee for permission to include such courses.

Notes

Elective I cannot be a required course in the student's major. It may be
1. Any required or additional track elective course selected from any of the five Biomedical Engineering tracks. See the online catalog (https://www.cmu.edu/bme/Academics/Undergraduate%20Programs/Resources/catalog.html) for a listing of courses.
2. Any 42-xxx course with a 42-300 or higher number and worth at least 9 units.
3. 42-203 Biomedical Engineering Laboratory (or the cross-listed version 03-236 for students in the Health Professions Program). The course has a limited capacity and priority is given to students who have declared the Additional Major in Biomedical Engineering.
4. One semester of 42-200 Sophomore BME Research Project, 42-300 Junior BME Research Project, 42-400 Senior BME Research Project or 39-500 CIT Honors Research Project. The project must be supervised by a core or courtesy Biomedical Engineering faculty member and for 9 or more units.

Elective II must be a Biomedical Engineering Required or additional track elective.

Priority for enrollment in 42-203 or 03-206 will be given to students who have declared the Additional Major in Biomedical Engineering. If sufficient room in the course remains after all majors have been accommodated in a given semester, students who have declared the Biomedical Engineering Designated Minor will be given the next priority for enrollment. If space still allows, other students will be enrolled.

Electronic Materials Minor

Lisa M. Porter, Director
Location: Roberts Engineering Hall 145

Many of the technological changes in recent decades—notably the rise of digital data processing—have been made possible by continuing advances in the performance of electronic devices. These advances include continuous improvement in microprocessor performance, optical communication bandwidth, and magnetic disk storage capacity. Other new areas of innovation include the development of micromechanical systems and the development of flat panel display technology. These advances depend on interactions between engineers from many different disciplines. In particular, there is a strong interaction between device design and materials engineering and processing.

The Electronic Materials Minor is intended to provide students with a firm basis for the application of electronic materials in advanced systems. This minor is well suited for students who intend to pursue careers in the electronics industry (included, but not limited to, semiconductor integrated circuit design and manufacturing, and magnetic storage engineering). The minor also provides an excellent preparation for students interested in pursuing graduate work in MSE, ECE, or Applied Physics.

This minor is primarily intended to offer ECE and MSE students an understanding of the important features that must be built into a material during processing so that it will function as required in an electronic or magnetic device. Other students interested in pursuing this minor should consult their advisors to determine whether it will be practical in their own curriculum. Such students are expected to take both 18-100 and 27-201 as introductory courses.

Course Requirements

Required units for minor: 66

The minor requires an introductory course together with a minimum of 45 additional units as specified below.

Required Introductory Courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>18-100 Introduction to Electrical and Computer Engineering</td>
<td>12</td>
</tr>
<tr>
<td>27-201 Structure of Materials</td>
<td>9</td>
</tr>
</tbody>
</table>

45 Additional Units From the Following Electives List:

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>27-202 Defects in Materials (ECE students only)</td>
<td>9</td>
</tr>
<tr>
<td>18-310 Fundamentals of Semiconductor Devices</td>
<td>12</td>
</tr>
<tr>
<td>06-619 Semiconductor Processing Technology</td>
<td>9</td>
</tr>
<tr>
<td>27-542 Processing and Properties of Thin Films</td>
<td>9</td>
</tr>
<tr>
<td>27-533 Principles of Growth and Processing of Semiconductors</td>
<td>6</td>
</tr>
<tr>
<td>27-432 Electronic and Thermal Properties of Metals, Semiconductors and Related Devices</td>
<td>9</td>
</tr>
</tbody>
</table>
Global Engineering Minor
Treci Bonime, Director
Office: Scaife Hall 120

Many engineers work on international projects or for multinational companies. Carnegie Mellon is an international community, with a significant fraction of international students and many events featuring foreign speakers and cultural experiences. This minor is intended for engineering students interested in broadening their background in international experiences and global awareness and engagement.

Course Requirements

International Management (1 course)
Complete one course in international management or business such as:

- 70-342 Managing Across Cultures 9
- 70-365 International Trade and International Law 9
- 70-381 Marketing I 9
- 70-430 International Management 9
Or approved equivalent

Regional Specialization (1 course)
Complete one course in non-US History, international politics, or literature in a single region of the world. See the list at http://www.cit.cmu.edu/global/courses_degrees.html below for examples (Note: Please consult with the Global Engineering director before planning your course schedule, as some course information may have changed).

- 70-332 Business, Society and Ethics 9
- 80-136 Social Structure, Public Policy & Ethics 9
- 80-244 Environmental Ethics 9
Or approved equivalent

Modern Languages
Demonstration of basic competency in a foreign language via one of the three options listed below:

- Complete one (1) Modern Languages course at the 200 level, with a minimum grade of C, or
- Achieve a score of 4 or higher in one foreign language Advanced Placement examination, or
- Demonstrate equivalent proficiency to the satisfaction of the Department of Modern Languages

Study/Work Abroad
Study or engineering internship work abroad for a semester or a summer. The region visited should be consistent with the language and regional culture/history studied.

Materials Science and Engineering Minor
Michael E. McHenry, Director
Location: Roberts Engineering Hall 243
Paige Houser, Academic Advisor
Location: Wean Hall 3317

The Designated Minor in Materials Science and Engineering provides the CIT student with a background in the field of Materials Science and Engineering. This minor is open to all CIT students, with the exception of MSE majors. All required and elective courses are taught within the MSE Department.

Course Requirements

Minimum units required for minor 45
The minor requires a minimum of 45 units, with two semester long required courses (the first being a sequence of two minis).

Prerequisites
Students wishing to take the MSE minor must have prerequisite thermodynamics and transport courses. The prerequisite MSE courses may be substituted for by a thermodynamics and transport course in another engineering discipline.

Core Courses (21 units)

- 27-211 Structure of Materials (Minor Option) 6
- 27-212 Defects in Materials (Minor Option) 6
- 27-227 Phase Relations and Diagrams (Minor Option) 9

The laboratories with these courses are not required as core but will be counted as elective units if desired.

Elective Courses (24 units minimum)

The student must select a minimum of 24 units from the following list:

- 27-100 Engineering the Materials of the Future 12
- 27-301 Microstructure and Properties I 9
- 27-311 Polymers and Materials 9
- 27-323 Powder Processing of Materials 9
- 27-324 Introduction to Polymer Science and Engineering 9
- 27-357 Introduction to Materials Selection 6
- 27-367 Selection and Performance of Materials 6
- 27-582 Phase Transformations in Solids 9
- 27-433 Dielectric, Magnetic, Superconducting Properties of Materials & Related Devices 9
- 27-421 Processing Design 6
- 27-591 Mechanical Behavior of Materials 9
- 27-454 Supervised Reading Var.
- 27-533 Principles of Growth and Processing of Semiconductors 6
- 27-555 Materials Project I Var.
- 27-542 Nanostructured Materials 9
- 27-541 Processing and Properties of Thin Films 9
- 27-551 Properties of Ceramics and Glasses 9
- 27-566 Special Topics in MSE: Using Matls Informatics to Assess Societal Impact of Matls 9
- 27-592 Solidification Processing 9
- 42-444 Medical Devices 9
Mechanical Behavior of Materials Minor

Program Contacts
Warren M. Garrison, Jr., Director
Paige Houser, Academic Advisor

An understanding of mechanical behavior is important to both the development of new materials and the selection of appropriate materials for many applications. The mechanical behavior of materials is best investigated and understood by integrating solid mechanics with the microstructural basis of flow and fracture. The purpose of this minor is to allow a formal basis for students to pursue an integrated approach to the mechanical behavior of materials.

Although this minor is open to all CIT students, only students in the departments of Civil Engineering, Materials Science and Engineering, and Mechanical Engineering can take advantage of the double counting permitted for some courses in their department majors. Students in other departments may have difficulty in fulfilling the requirements in four years.

Department Contacts
Paul S. Sides, Chemical Engineering
Rachel Amos, Electrical and Computer Engineering
Paul S. Steif, Mechanical Engineering
Warren M. Garrison, Jr., Materials Science and Engineering

Course Requirements
Minimum units required for minor 51-54

The minor requires six courses: three core courses, two solid mechanics courses, and one materials science course. In satisfying these course requirements, each student must take three out-of-department courses. Each student is required to complete three core courses:

Core Courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>27-201</td>
<td>Structure of Materials</td>
<td>9</td>
</tr>
<tr>
<td>27-591</td>
<td>Mechanical Behavior of Materials</td>
<td>9-12</td>
</tr>
<tr>
<td>or 27-791</td>
<td>Mechanical Behavior of Materials</td>
<td>9-12</td>
</tr>
<tr>
<td>12-212</td>
<td>Statics</td>
<td>9</td>
</tr>
<tr>
<td>or 24-261</td>
<td>Statics</td>
<td>9</td>
</tr>
</tbody>
</table>

Group A: Materials Science Courses
Each student must take one course from this list of Materials Science courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>27-202</td>
<td>Defects in Materials</td>
<td>9</td>
</tr>
<tr>
<td>27-357</td>
<td>Introduction to Materials Selection</td>
<td>6</td>
</tr>
<tr>
<td>27-551</td>
<td>Properties of Ceramics and Glasses</td>
<td>9</td>
</tr>
<tr>
<td>42-411</td>
<td>Engineering Biomaterials</td>
<td>9</td>
</tr>
</tbody>
</table>

1 27-202 cannot be used by MSE students to satisfy the requirements of the minor.
2 27-357 cannot be used by MSE students to satisfy the requirements of the minor.

Group B: Solid Mechanics Courses
Each student must take two of the following Solid Mechanics courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-231</td>
<td>Solid Mechanics</td>
<td>9</td>
</tr>
<tr>
<td>or 24-262</td>
<td>Stress Analysis</td>
<td>9</td>
</tr>
<tr>
<td>12-635</td>
<td>Structural Analysis</td>
<td>9</td>
</tr>
<tr>
<td>or 24-351</td>
<td>Dynamics</td>
<td>9</td>
</tr>
</tbody>
</table>

Students should check with the director of the program or their faculty advisor for an up-to-date list of relevant courses that will count towards this minor. For more information, please consult the Undergraduate Course Catalog and the current Schedule of Classes.