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
- Environmental Engineering
- Global Engineering
- Materials Science and Engineering
- Mechanical Behavior of Materials
- Robotics (see "CIT Minors for Non-Engineering Students (http://coursecatalog.web.cmu.edu/carnegieinstituteoftechnology/minorsfornonengineeringstudents)")

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 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**
Engineering and Public Policy	**Deanna Hart Matthews**
Materials Science and Engineering	**Anthony Rollett**
Mechanical Engineering	**Jack Beuth**

Course Requirements

This minor requires a total of five (5) courses comprising of three core courses and two technical electives.

Core Courses 3 courses, 36 units

		Units
39-601	Special Topics: Additive Manufacturing Processing and Product Development	12
39-602	Materials Science for Additive Manufacturing	12
39-603	Additive Manufacturing Laboratory	12

Technical Electives 2 courses

To select acceptable technical elective course options, please speak with your departmental contact, or see https://engineering.cmu.edu/next/education-training.html.

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	
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.

(choose 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

** prerequisites 18-220 and 18-290.

(choose 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	
18-320	Microelectronic Circuits +	12
18-349	Introduction to Embedded Systems **	12

* prerequisite 18-290.

** prerequisite 18-240 and 18-213.

+ prerequisite 18-220.

Automation and Controls Minor

Erik Ydstie, Director and Faculty Advisor

Office: DH 4210 A

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 the 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:		Units
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
18-771	Linear Systems	12
One course on computing and software		
12-741	Data Management	6
18-649	Distributed Embedded Systems	12
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
15-381	Artificial Intelligence: Representation and Problem Solving	9
15-385	Introduction to Computer Vision	6
15-413	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
18-771	Linear Systems	12
24-341	Manufacturing Sciences	9

Biomedical Engineering Minor

Associate Department Head

Professor Conrad M. Zapanta
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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 studies 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 two or three electives. Students pursuing the minor may contact BME Associate Head (http://www.bme.cmu.edu/people/staff.html#ADH) for advice. Students interested in declaring Biomedical Engineering minor should contact either the Associate Department Head (http://www.bme.cmu.edu/people/staff.html#ADH) of Biomedical Engineering or the Biomedical Engineering Undergraduate Program Coordinator (http://www.bme.cmu.edu/people/staff.html#UPC).

Requirements

Minimum units required for minor: 57

03-121	Modern Biology	9
42-101	Introduction to Biomedical Engineering (co-req. or pre-req. 03-121)	12
42-202	Physiology (pre-req. 03-121 or permission of instructor)	9
42-xxx	BME Elective (>= 9 units), Any course offered by the Department of Biomedical Engineering numbered 42-300 or higher and worth at least 9 units	
xx-xxx	Elective I (>= 9 units) [#]	
xx-xxx	Elective II (>= 9 units) [+]	

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 four Biomedical Engineering tracks. See the online catalog (http://www.bme.cmu.edu/ugprog/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 03-206 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 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.

Colloids, Polymers and Surfaces Minor

Annette Jacobson, Director
Office: Doherty Hall 3102B
Website: http://www.cit.cmu.edu/current_students/services/majors_minors/engineering_minors/cps.html

The sequence of courses in the Colloids, Polymers and Surfaces (CPS) designated minor provides an opportunity to explore the science and engineering of fine particles and macromolecules as they relate to complex fluids and interfacially engineered materials. These topics are very relevant to technology and product development in industries that manufacture pharmaceuticals, coatings and paints, pulp and paper, biomaterials, surfactants and cleaning products, cosmetics and personal care products, food, textiles and fibers, nanoparticles, polymer/plastics, composite materials.

Course Requirements

Minimum units required for minor: 45

This minor requires a total of five classes. The following four courses are mandatory:

06-609/09-509	Physical Chemistry of Macromolecules	9
06-607	Physical Chemistry of Colloids and Surfaces	9
06-426	Experimental Colloid Surface Science	9
06-466	Experimental Polymer Science	9

In addition, the student must take one course* from the following list:

06-221	Thermodynamics [*]	9
24-221	Thermodynamics I	10
27-215	Thermodynamics of Materials	12
33-341	Thermal Physics I	10
09-345	Physical Chemistry (Thermo): Macroscopic Principles of Physical Chemistry	9

[*] Chemical Engineering majors should take 06-221 to fulfill this requirement.

Electronic Materials Minor

Lisa M. Porter, Director
Office: Roberts Engineering Hall 145
Website: http://engineering.cmu.edu/current_students/services/majors_minors.html

Many of the technological changes in recent decades-notably the rise of digital data processing-has 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 pursing 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:

18-100	Introduction to Electrical and Computer Engineering	12
27-201	Structure of Materials	9

45 Additional Units From the Following Electives List:

27-202	Defects in Materials (ECE students only)	9
18-310	Fundamentals of Semiconductor Devices	12
06-619	Semiconductor Processing Technology	9
27-542	Processing and Properites of Thin Films	9
27-533	Principles of Growth and Processing of Semiconductors	6
27-432	Electronic and Thermal Properties of Metals, Semiconductors and Related Devices	9
27-433	Dielectric, Magnetic, Superconducting Properties of Materials & Related Devices	9
18-403	Microfabrication Methods and Technology	12
18-614	Microelectromechanical Systems	12
33-225	Quantum Physics and Structure of Matter	9
xx-xxx	An approved research project on electronic materials	6-12
xx-xxx	An approved special topics or graduate level class pertaining to electronic materials	6-12

Environmental Engineering and Sustainability Minor

Neil M. Donahue, Director
Office: Doherty Hall 2116

Concern for the environment now influences a wide range of public, private and engineering decisions. Environmental Engineering is widely recognized as a discipline at the graduate and professional level, and undergraduate training in environmental issues and processes can provide the preparation necessary to pursue this career path, or serve as a useful complement to a career in any of the traditional areas of engineering. Sustainability issues are not considered critical across engineering disciplines.Effective preparation requires broad knowledge and skills in the areas of environmental engineering, sustainability, and environmental policy.

Faculty Advisors

The Environmental Engineering and Sustainability program is a focus for faculty members from diverse engineering backgrounds. The faculty are actively engaged in teaching and conducting research in this field. Current faculty advisors are:

- Biomedical Engineering — Robert Tilton
- Chemical Engineering – Neil Donahue
- Civil and Environmental Engineering — Peter Adams and Scott Matthews
- Electrical and Computer Engineering — Marija Ilic
- Engineering and Public Policy — Edward Rubin
- Mechanical Engineering — Ryan Sullivan
- Materials Science and Engineering — Robert Heard

To declare this minor, please speak with a faculty advisor and then contact Andrea Francioni Rooney in the Department of Civil and Environmental Engineering.

Course Requirements

Minimum units required for minor 66

The requirements include two core courses, three technical electives, and two policy electives.

A1. Core Courses in Sustainability 12 units

Select one course from:

12-712/19-717	Introduction to Sustainable Engineering	12
12/19-714	Environmental Life Cycle Assessment	12

A2. Core Courses in Environmental Engineering 9 units

Select one course from:

12-351	Environmental Engineering [See note 4]	9
24/19-424	Energy and the Environment	9
12-651	Air Quality Engineering	9
24-425	Combustion and Air Pollution Control	9
12-702	Fundamentals of Water Quality Engineering	12

B. Technical Electives in Environmental Engineering and Sustainability 27 units

Select three from the following list:

03-121	Modern Biology	9
09-106	Modern Chemistry II	10
09-510	Chemistry and Sustainability	9
12-201	Geology	9
12-351	Environmental Engineering [see note 4]	9
12-651	Air Quality Engineering	9
12-657	Water Resource Systems Engineering	9
12-702	Fundamentals of Water Quality Engineering	12
12-712/19-717	Introduction to Sustainable Engineering	12
12/19-714	Environmental Life Cycle Assessment	12
12-718	Environmental Engineering, Sustainability, and Science Project	12
24/19-424	Energy and the Environment	9
24-425	Combustion and Air Pollution Control	9
27-367	Selection and Performance of Materials *	6
27-421	Processing Design *	6
48-315	Environment I: Climate & Energy	9

* 6 units; must be combined with 3 additional units

C. Policy Electives 18 units

Select two from the following list of humanities/social science-oriented courses:

06/19-365	Water Technology Innovation and Policy	9
19-421	Emerging Energy Policies	9
19-425	Sustainable Energy for the Developing World	9
19-653	Climate Change Mitigation	12
19-665	Environmental Politics and Policy *	6
19-666	Energy Policy and Economics *	6
76-425	Science in the Public Sphere	9
76-476	Rhetoric of Science	9
79-369	Disasters in American History: Floods and Hurricanes *	6
79-336	Oil & Water: Middle East Perspectives	6
79-370	Disasters in American History (2):Epidemics & Fires *	6
80-244	Environmental Ethics	9
88-220	Policy Analysis I	9
88-221	Analytical Foundations of Public Policy	9
88-223	Decision Analysis	9
90-765	Cities, Technology and the Environment *	6
90-789	Sustainable Community Development	12
90-798	Environmental Policy & Planning	12

* 6 units; must be combined with 3 additional units

NOTES:

1. Courses cannot be double-counted for lists A and B.
2. Courses used to fulfill the first year restricted technical electives for CIT **cannot** be double counted for list B requirements
3. A group of three environmental policy courses, from List C, excluding Heinz courses, may be counted as fulfilling the general education depth requirement required of all CIT students if and only if the student completes the Environmental Engineering and Sustainability Minor. Approval of the selected courses from List C for fulfillment of this CIT depth sequence is required from the student's home department advisor.
4. Courses required within a student's CIT major **can** be double counted for list A or B course requirements, with the exception that 12-351 Environmental Engineering can be counted toward completion of the minor for non-CEE students only.
5. Students may take up to two list B courses in their home department. One list B course must be from outside their home department. EPP double majors should NOT consider EPP their home department. BME double majors should NOT consider BME their home department.
6. At most ONE 48-xxx course can be used as a List B course and one as a List C course. The 48-xxx courses may not be acceptable as technical electives by some CIT engineering departments.
7. Other environmentally related technical electives with similar or related content may be substituted for List B courses **only** with written permission of the Director.
8. Other humanities and social science courses with similar or related content may be substituted for Type C courses **only** with written permission of the Director.
9. A list of available courses for the minor in each semester is provided to students who have declared the minor and to all faculty advisors for the minor.

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
88-384	Conflict and Conflict Resolution in International Relations	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).

Ethics (1 course)

Any ethics course that provides some exposure to international ethics issues such as:

70-332	Business, Society and Ethics	9
80-136	Social Structure, Public Policy & Ethics	9
80-244	Environmental Ethics	9
80-247	Ethics and Global Economics	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
Office: Roberts Engineering Hall 243

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
27-217	Phase Relations and Diagrams	12

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	Polymeric Biomaterials	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
27-432	Electronic and Thermal Properties of Metals, Semiconductors and Related Devices	9
27-421	Processing Design	6
27-445	Structure, Properties and Performance Relationships in Magnetic Materials	9
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.
27-565	Nanostructured Materials	9
27-542	Processing and Properites 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

Warren M. Garrison, Jr., Director
Office: Wean Hall 3303

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.

Faculty Advisors

- Chemical Engineering — Paul Sides
- Electrical and Computer Engineering — David W. Greve
- Mechanical Engineering — Paul S. Steif
- Materials Science and Engineering — Warren M. Garrison, Jr.

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:

27-201	Structure of Materials	9
27-591	Mechanical Behavior of Materials	9-12
or 27-791	Mechanical Behavior of Materials	
12-212	Statics	9
or 24-261	Statics	

Group A: Materials Science Courses

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

27-202	Defects in Materials [1]	9
27-357	Introduction to Materials Selection [2]	6
27-551	Properties of Ceramics and Glasses	9
42-411	Engineering Biomaterials	9

[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:

12-231	Solid Mechanics	9
or 24-262	Stress Analysis	
12-635	Structural Analysis	9
or 24-351	Dynamics	

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.