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
- Biomedical Engineering
- Colloids, Polymers and Surfaces
- 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

Paige Houser, Academic Advisor

Departmental Contacts

Biomedical Engineering	**Robert Tilton**
Chemical Engineering	**Robert Tilton**
Electrical and Computer Engineering	**Maysam Chamanzar**
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.

Three Core Courses 36 units

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

Two Technical Electives

To select acceptable technical elective course options, please speak with your departmental contact, or see https://engineering.cmu.edu/education/undergraduate-programs/curriculum/additive-manufacturing-minor.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, 43-49 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
or 57-171	Introduction to Music Technology (self-paced)	
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
18-490	Electroacoustics **	12

** prerequisites 18-220 and 18-290.

(choose one of the courses below)		Units
18-300	Fundamentals of Electromagnetics	12
18-341	Logic Design and Verification	12
18-370	Fundamentals of Control	12
18-491	Digital Signal Processing	12
15-210	Parallel and Sequential Data Structures and Algorithms	12
15-214	Principles of Software Construction: Objects, Design, and Concurrency	12
18-320	Microelectronic Circuits +	12
18-349	Introduction to Embedded Systems ***	12

\+ prerequisite 18-220.

*** prerequisites 18-240 and 18-213.

Biomedical Engineering Minor

Kristin Kropf, *Undergraduate Program and Alumni Relations Coordinator, Biomedical Engineering*
kgaluska@andrew.cmu.edu
www.cmu.edu/bme/Academics/undergraduate-programs/minor.html (https://www.cmu.edu/bme/Academics/undergraduate-programs/minor.html)

The minor program is designed for students who desire exposure to biomedical engineering but may not have the time to pursue the Biomedical Engineering additional major. The program is open to students of **all** colleges and is popular among both engineering and 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 three electives. The Quality Point Average (QPA) for courses that count toward the minor must be 2.00 or better. No course taken on a pass/fail or audit basis may be counted towards the minor.

Students who have questions or are interested in declaring Biomedical Engineering minor should contact Kristin Kropf (kgaluska@andrew.cmu.edu).

Requirements

Minimum units required for minor: 57

03-121	Modern Biology	9
or 03-151	Honors Modern Biology	
42-101	Introduction to Biomedical Engineering	12
42-202	Physiology	9
42-xxx	BME Elective I	9-12
42-xxx	BME Elective II	9-12
42-xxx	BME Elective III	9-12

A BME Elective is defined as one of the following:

1. 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. Research projects supervised by a courtesy Biomedical Engineering faculty member must have significant biomedical engineering relevance. Note that BME Research Project can only be count as one BME elective.

2. 42-203 BME Laboratory (or the cross-listed version 03-206 for students in the Health Professions Program). Please note that 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.

3. Any 42-xxx course with a course number greater than 42-300 and worth at least 9 units (excluding 42-300 and 42-400- see previous comment regarding BME Research Project).

Students can petition the Biomedical Engineering Undergraduate Affairs Committee to count non-BME classes that have significant biological or medical content towards the minor requirements.

Colloids, Polymers and Surfaces Minor

Professor Robert Tilton, *Director of CPS Minor*
Location: Doherty Hall A207C

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 with a minimum of 45 units. 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 CPS related elective course from the following list:

06-612	Formulation Engineering	12
06-610	Rheology and Structure of Complex Fluids	9
09-502	Organic Chemistry of Polymers	9
27-565	Nanostructured Materials	9
27-477	Introduction to Polymer Science and Engineering	9

Other CPS electives are possible but must be approved by the Director of the CPS minor, Professor Tilton

Electronic Materials Minor

Jim Bain, *Co-Director*
Marek Skowronski, *Co-Director*
Paige Houser, *Academic Advisor*

Electronic materials are ubiquitous and essential in 21st century society. They underpin technologies that we rely on everyday – everything from communication, transportation, and lighting to commerce and entertainment. Advances in the synthesis, processing, and design of electronic materials are continuing to push boundaries towards more energy-efficient technologies, such as neuromorphic and quantum computing, long-range electric vehicles, AI, renewable energy sources, and other yet-to-be-discovered applications.

The Electronic Materials (EM) Minor is designed for students who have a keen interest in electronic materials, such as semiconductors, dielectrics and magnetics, and who are considering graduate school studies or careers pertaining to electronic materials industries. Students in the EM Minor will choose from a list of course electives from which they will learn about the physics, chemistry, synthesis, processing, design, characterization, and applications of a wide variety of electronic materials and devices.

Course Requirements

Minimum units for minor 54

54 Units From the Following Electives * :

27-100	Engineering the Materials of the Future ECE students only)	12
or 27-201	Structure of Materials	
or 27-211	Structure of Materials (Minor Option)	
18-100	Introduction to Electrical and Computer Engineering (MSE students only)	12
27-202	Defects in Materials (ECE students only)	9
or 27-212	Defects in Materials (Minor Option)	
27-432	Electronic and Thermal Properties of Metals, Semiconductors and Related Devices	9
27-433	Dielectric, Magnetic, Superconducting Properties of Materials & Related Devices	9
27-445	Structure, Properties and Performance Relationships in Magnetic Materials	9
27-533	Principles of Growth and Processing of Semiconductors	6
27-542	Thin Film Technologies	9
18-220	Electronic Devices and Analog Circuits	12
18-300	Fundamentals of Electromagnetics	12
18-310	Fundamentals of Semiconductor Devices	12
33-225	Quantum Physics and Structure of Matter	9
xx-xxx	An approved special topics or graduate level class pertaining to electronic materials	6-12

xx-xxx	An approved research project on electronic materials	6-12

*Students in ECE must take a minimum of 9 units in MSE, students in MSE must take a minimum of 9 units in ECE.

Global Engineering Minor

Treci Bonime, Director
Office: Scaife Hall 424

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 https://engineering.cmu.edu/education/undergraduate-programs/curriculum/global-courses-minors.html (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

Or approved equivalent

Languages, Cultures, and Applied Linguistics

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

- Complete one (1) Languages, Cultures, and Applied Linguistics 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 Languages, Cultures, and Applied Linguistics

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.

Information Security, Privacy and Policy Minor

Lujo Bauer, *Professor, Electrical and Computer Engineering and Software and Societal Systems Department (SCS)*

Deanna H. Matthews, *Associate Department Head for Undergraduate Affairs, Engineering and Public Policy (CIT)*

Interdisciplinary minor offered by both CIT and SCS

There is a growing demand for security and privacy experts, and increasing interest among CMU undergraduates in taking security and privacy courses. Security and privacy expertise is an asset in a variety of careers outside, not just in computer science, but also in areas that include business, management, and law. In addition, the policy side of security and privacy is becoming increasingly important and employers are interested in hiring people with an understanding of relevant policy issues, especially in the privacy and security area.

This minor is for undergraduate students across the university who are interested in policy issues related to security and privacy, including those who are planning careers in security/privacy as well as those who plan to focus their careers in other areas. The curriculum has been designed to accommodate students from any major as long as they have taken at least one introductory-level college programming course (such as 15-110 or 15-112).

After completing this minor, students will have a good understanding of how to identify potential security and privacy risks and relevant legal and policy issues; a working understanding of security topics such as cryptography, authentication, and Internet security protocols; as well as broad knowledge of several security- and privacy-related areas as they pertain to the design, development, deployment and management of technologies in a variety of practical contexts (e.g., Web, mobile, Internet of Things, social media, crypto currencies).

Admission

Students are not required to apply to enroll in this minor to start the required courses. However, they are encouraged to consult with the minor director on their elective course selection. In addition, students doing the independent study option must get approval from the minor director prior to enrolling in their independent study course. Finally, students must contact the minor director to certify their completion of the minor.

Curriculum

Students are required to take five courses to complete this minor with a minimum of 48 units.

INTRODUCTORY SECURITY COURSE

17-331	Information Security, Privacy, and Policy	12

Students who have taken 15-213 Introduction to Computer Systems may substitute 15-330 Introduction to Computer Security/18-330 Introduction to Computer Security

PRIVACY AND POLICY COURSE

17-333	Privacy Policy, Law, and Technology	9

Students may substitute a 12-unit version of this course: 19-608, 17-333, or 95-818.

PRIVACY ELECTIVES

Complete a minimum of 9 units:		Units
19-534	Usable Privacy and Security	9
19-602	Current Topics In Privacy Seminar	3
17-731	Foundations of Privacy	12

TECHNOLOGY AND POLICY ELECTIVES

Complete a minimum of 9 units:		Units
19-211	Ethics and Policy Issues in Computing	9
19-101	Introduction to Engineering and Public Policy	12
19-402	Telecommunications Technology and Policy for the Internet Age	12
17-562	Law of Computer Technology	9
19-403	Policies of Wireless Systems	12
19-639	Policies of the Internet	12
84-387	Remote Systems and the Cyber Domain in Conflict	9

Crosslisted courses are also allowed.

ADDITIONAL APPROVED ELECTIVE

Students must complete an additional elective of 9 units or more. Students may choose an additional privacy elective or technology policy elective from the list above, or the one of the following security electives:

15-316	Software Foundations of Security and Privacy	9
15-356	Introduction to Cryptography	12
19-303	Cryptocurrencies, Blockchains and Applications	9
19-534	Usable Privacy and Security	9
18-334	Network Security	12
18-335	Secure Software Systems	12
18-435	Foundations of Blockchains	12

Students who have the necessary prerequisites may choose any approved elective from the SCS or ECE security and privacy undergraduate concentration. Check with the minor program director to determine which category of elective each course will fulfill.

Students should be careful to choose electives for which they have appropriate prerequisites. New elective options are expected as more courses are offered. Students may petition to count a course not on this list as an elective. Students should request permission *before* taking a course that is not on this list. Students may not count multiple electives that overlap substantially.

Optional Project: Subject to approval by the minor director, students may optionally count towards one of the elective requirements 9 units of an independent study or research project course in the security or privacy area, under the supervision of a faculty member in any department. In order to receive credit towards the minor, students must submit a brief project proposal to their project advisor and to the minor director and have it approved prior to conducting the project. Depending on the topic of the project, the minor director may approve credits counting towards privacy electives, technology policy electives, security electives, or some combination of these. Students may work individually, with other undergraduates, or as part of project teams with graduate students or research staff. Students involved in a group project must identify specific project components for which they are responsible. In addition, they must submit a final project report to their project advisor and the minor director that includes a literature review and describes the work they completed. Students working on a group project must each submit their own final report, which should also situate their contribution in the context of the larger project. Note, students are expected to work approximately 1 hour per week for each unit of project in which they are enrolled (e.g. 9 units = 9 hours/week of project work).

Double Counting: At most 2 of the courses used to fulfill the minor requirements may be counted towards any other undergraduate major or minor program. This rule does not apply to courses counted for general education requirements.

Materials Science and Engineering Minor

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.

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
27-570	Polymeric Biomaterials	12
27-477	Introduction to Polymer Science and Engineering	9
27-357	Introduction to Materials Selection	6
27-367	Selection and Performance of Materials	6
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	Mechanics 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	Thin Film Technologies	9
27-592	Solidification Processing	9
42-444	Medical Devices	9

Mechanical Behavior of Materials Minor

Program Contacts

Paige Houser, *Academic Advisor*

Paul S. Steif, *Mechanical Engineering*

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.

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	Mechanics of Materials	9-12
or 27-791	Mechanical Behavior of Materials	
12-212	Statics	9
or 24-261	Mechanics I: 2D Design	

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
27-709	Biomaterials	12

[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	Mechanics II: 3D Design	
12-635	Structural Analysis	12
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.